27.

Deep-sea Fishes of the Bermuda Oceanographic Expeditions. Family Nemichthyidae[1].

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(Text-figures 1-22).

Introduction.

For detailed data in regard to nets, locality, dates, etc., concerning the capture of the deep-sea eels treated in this monograph, refer to *Zoologica*, Vol. XIII, Nos. 1, 2 and 3, and Vol. XX, No. 1, pp. 1-2. For physical data, methods of measurement and definitions of growth stages, see *Zoologica*, Vol. XVI, No. 1.

The drawings are the work of George Swanson.

We wish Dr. L. P. Schultz and Dr. Thomas M. Barbour to accept our thanks for their cooperation in enabling us to examine specimens deposited in the United States National Museum and in the Museum of Comparative Zoology.

Important Points in the Following Study of the Nemichthyidae.

Taxonomy: 1. Contrary to recent opinions that the genus *Nemichthys* is mono-specific, we conclude that it contains at least two species, *Nemichthys scolopaceus* Richardson of cosmopolitan distribution, and *Nemichthys fronto* Garman from the eastern Pacific.

2. There are two valid Atlantic species of *Avocettina, A. infans* Günther of presumably cosmopolitan distribution and *A. exophthalma* Parr from the West Indies; in addition, at least one undescribed species is probably included among the examples of this genus already recorded from the Atlantic. The third known Atlantic species, *A. elongata* (Gill and Ryder), is synonymous with *A. infans*. *A. bowersii* Garman, from the eastern Pacific, is valid, as is probably *A. gilli* (Bean) from Alaska. The final decision concerning the latter species, however, must await a redefinition of *A. infans*.

3. The development of *Nemichthys* is traced through a consecutive series of stages, proving that the form "Leptocephalus B," considered by Roule and Bertin (1929) to be a giant albino or variable larva of *Nemichthys scolopaceus*, belongs to a different species and probably a different genus; the same is true of some of the older larvae described in their report.

4. The specimens recorded by Borodin (1931, pp. 73-74) as *Tilurella Nemichthydis infantis, Nemichthys infans* and *Serrivomer sector* are all

[1] Contribution No. 547, Department of Tropical Research, New York Zoological Society. Contribution, Bermuda Biological Station for Research, Inc.

post-larval and adolescent specimens of *Nemichthys scolopaceus*. *Nemichthys* sp., described in the same place, is a transitional adolescent *S. beanii*.

Structure: 1. The teeth of *Nemichthys* are set in curving bands, rather than in the quincunx formation typical of *Avocettina* and *Labichthys*.

2. The skeleton of *Labichthys* is less specialized than those of the other genera.

3. Coelomic organs are unpigmented in *Avocettina*.

4. Although *Labichthys* and *Avocettina* are more closely related to each other than to *Nemichthys*, *Nematoprora* and *Cercomitus*, yet these genera have far more osteological similarities than differences when compared with their near neighbors, the Serrivomeridae and Cyemidae. Hence they are included in a single family, the Nemichthyidae.

Ecology: 1. Next to *Serrivomer beanii* and *Eurypharynx pelecanoides*, *Nemichthys scolopaceus* is the most common deep-sea eel found in our Bermuda trawling area, 45 specimens having been taken in the nets. *Labichthys*, on the other hand, is represented by only three specimens and *Avocettina* by one.

2. Young, six-inch nemichthyid eels (provisionally identified as *Labichthys*) were recognized from the bathysphere at a depth of only 75 fathoms, far above the level at which specimens of this size have been taken in the nets (500 to 1,000 fathoms).

Family Nemichthyidae.

Characteristics: Naked deep-sea eels with the body extremely slender and jaws excessively attenuated; snout much more than half length of head; teeth small with backwardly directed, curving tips, numerous, set in curving bands or quincunxial rows; two pairs of large nostrils, the anterior with short tube, close in front of eye; nuchal constriction present; gill openings well developed, convergent forward; anus far in advance of middle of length; pectorals and vertical fins well developed; fin membranes thin, not enveloping rays; lateral line pores present or absent; caudal filament present or absent.

Skeleton moderately well developed; frontals united anteriorly; parietals separate or united; supraoccipital present or absent; pterotic large with sensory canal tube extending forward to overlap frontals; palatine absent; pterygoid much reduced or absent; hyomandibular and quadrate forming with the mandible an angle of slightly more than 90 degrees; anterior end of frontal intercalated with the divided posterior end of ethmo-vomer, the two prongs of which join or almost join above the frontal; mandible shorter than ethmo-vomer; maxillary very short, articulating with the excessively elongate ethmo-vomer near its base; opercular apparatus reduced and little ossified, the opercle alone being constantly present; preopercle always absent; hyoid and branchial apparati both reduced and feebly ossified, the pharygobranchials being strongest; branchiostegal rays 7 to 10; supracleithrum absent; cleithrum, coracoids and radials feebly or moderately ossified; vertical fins feebly supported, not well ossified; vertebrae numerous, increasing with age, 170 to more than 500.

Coelom relatively small; intestine curved forward on its own length; a single small caecum; stomach a blind sac; liver small, elongate; kidney extremely elongate; gonads dorsal, extending farther posteriorly than all other organs except kidney.

Affinities: As already pointed out in our discussion of the Serrivomeridae (*Zoologica*, Vol. XXII, No. 26, p. 346), the nemichthyids are in most respects more highly specialized than the serrivomerids, as is shown by

their extremely elongated jaws, attenuated bodies, more anteriorly placed anus, reduced or vestigial palato-pterygoid, opercular, hyoid and branchial apparatus, and more numerous vertebrae. Their teeth and comparatively strong pectorals, however, are characters less highly differentiated than in the serrivomerids.

In the Cyemidae the opercular and branchial apparatus is even more reduced than in the nemichthyids, although the jaws are similar. The excessive reduction of its vertebrae in a group noted for a high vertebral count leads to interesting speculations on ancestral forms.

Because of the close osteological relationships of *Nemichthys* and *Nematoprora* with *Avocettina* and *Labichthys* these four genera are at present, with *Cercomitus,* considered to form a single family (see below).

Taxonomic Discussion: Five genera have been described, *Nemichthys* Richardson (1848), *Labichthys* Gill and Ryder (1883), *Avocettina* Jordan and Davis (1888), *Nematoprora* Gilbert (1905) and *Cercomitus* Weber (1913). *Nemichthys* and *Avocettina* are of cosmopolitan distribution, *Labichthys* is known only from the Atlantic, and *Nematoprora* and *Cercomitus* have been taken only in the Pacific, although evidence is accumulating to show that one or both of these genera also occur in the Atlantic (see p. 361). The first three genera are all represented in the collections taken on the Bermuda Oceanographic Expeditions.

Key to the Genera.

A. Lateral line with pores.
  B. Three rows of tiny pores; caudal filament present; vertebrae not fewer than 300, usually many more.....*Nemichthys*
  BB. A single row of large pores; caudal filament absent; vertebrae not more than 200.
    C. Anal origin scarcely behind level of pectoral base.....*Labichthys*
    CC. Anal origin well behind level of pectoral base, the postorbital distance being contained more than one and three-quarters times the distance between pectoral base and anal origin. .....*Avocettina*

AA. Lateral line without pores.
  D. Gill slits narrow; backwardly directed points on teeth well developed, conspicuous.....*Cercomitus*
  DD. Gill slits wide, points on teeth small, inconspicuous.....*Nematoprora*

Genus ***Nemichthys*** Richardson, 1848.

Generic Characters: Nemichthyids with three rows of minute pores in the lateral line; caudal filament present; ethmo-vomerine teeth in eight longitudinal rows set in curving, transverse bands; anus and anal origin scarcely behind level of pectoral base; dorsal origin on occiput, in advance of level of pectoral base; dorsal rays in middle third of body short, spinous.

Parietals separated by suture; supraoccipital absent; pterygoid absent; mandible slightly shorter than ethmo-vomer; preopercle, subopercle and interopercle absent; glossohyal, basihyal and hypohyals absent; ceratohyal feebly ossified with eight strongly curved branchiostegals; branchial apparatus completely cartilaginous except for faintly ossified pharyngobranchials; basibranchials apparently absent; coracoid and four radials ankylosed, feebly ossified; cleithrum at level of fifth vertebra; vertebrae 300 (in young specimens) to 660.

Leptocephalus characterized by an elongate body, long snout (but not of characteristic *Nemichthys* attenuation), posteriorly placed anus, many myomeres and characteristic pigmentation (see pp. 357 ff.)

Discussion: In their monograph on the nemichthyid eels published in 1929, Roule and Bertin decided that, in spite of the tremendous differences in proportions and differences of range, all of the recorded specimens of *Nemichthys* belonged to a single species, *Nemichthys scolopaceus*, first described by Richardson in 1848. The extensive *Dana* collections, they reasoned, provided ample material for the study of variation, and they found, through numerous measurements, that the variations of each character gave a normal curve with a single, median node, and that specimens of various types were not confined to one geographical area: for example, specimens with very large eyes were taken in the same region with small- and medium-eyed examples.

Our careful examination of their evidence can find no flaw in their reasoning: the liability of both the jaws and caudal filament to injury leaves very few characters which can be accurately measured, the best of these being the relation of the diameter of the eye to the postorbital length of the head. Nevertheless, especially in the light of the presence of at least two forms of *Nemichthys*-like larvae (see pp. 357 ff.), it seems inevitable that two or more species are included in the *Dana* collection, and that at least one or two of the other species of *Nemichthys* synonymized by Roule and Bertin with *N. scolopaceus* will, in the light of future material, prove to be valid.

It may be stated here that *Nemichthys fronto*[2] Garman, 1899, from the west coast of central America appears to be perfectly valid: every single one of the *Dana* specimens from the Gulf of Panama (Roule and Bertin, 1929, Tables III and IV, pp. 14-15 and 17-18) have the small eyes (or large postorbital distances) characteristic of that species, the diameter being contained in the postorbital length of the head 3.6 to 5.3 times. Small-eyed specimens were, however, taken in the Atlantic as well.

The extremes of proportions, which include those of other authors as well within the *Dana* material, are as follows: Maximum height of trunk in length 39 to 200; head in length 9 to 21 times; caudal filament 2.3 to 6.3 times in length; length of snout in head 1.3 to 1.8; eye diameter in head length 7.4 to 18.2; eye diameter in snout length 4.5 to 13; diameter of eye in postorbital length 1.4 to 5.3; pectoral length in postorbital length 0.5 to 3.5.

It will be seen that all of these proportions far exceed normal ranges of specific variation. At present, nevertheless, we can only agree with Roule and Bertin—except that we maintain the validity of *N. fronto*—and refer the known specimens of the genus to *N. scolopaceus*.

The following species referable to *Nemichthys* have been described: *Nemichthys scolopaceus* Richardson (1848), *Leptorhynchus leuchtenbergi* Lowe (1852), *Belonopsis leuchtenbergi* Brandt (1854), *Nemichthys acanthonotus* Alcock (1892), *Nemichthys fronto* Garman (1899), *Nemichthys mediterraneus* Ariola (1904), *Leptocephalus canaricus* Lea (1913), *Leptocephalus andreae* Schmidt (1912) and *Tilurella gaussiana* Pappenheim (1914). *Nemichthys avocetta* Jordan and Gilbert (1880), since it apparently lacks a lateral line, probably belongs to another genus.

In addition to type descriptions, the chief references to this relatively well known genus of deep-sea eels are the following. *Nemichthys scolopaceus*: Günther (1887), Vaillant (1888), Goode and Bean (1895), Jordan

[2] We have examined the type specimen, deposited in the Museum of Comparative Zoology, and found the original description to be accurate.

and Evermann (1896), Brauer (1906), Roule and Bertin (1929), Norman (1930) and Borodin (1931)[3].

Nemichthys has previously been taken from the western Atlantic by the *Blake* (Goode and Bean, 1895), by fishermen (Mowbray, 1922), by the *Dana* (Roule and Bertin, 1929) and by the *Atlantis* (Borodin, 1931).

In the following pages a description is given of the largest (transitional adolescent) Bermuda specimens as well as of a series of growth stages taken in the same locality.

Nemichthys scolopaceus Richardson, 1848.

Specimens Taken by the Bermuda Oceanographic Expeditions.

45 specimens; April to September, 1929 to 1931; 50 to 1,000 fathoms; from a cylinder of water 8 miles in diameter (5 to 13 miles south of Nonsuch Island, Bermuda), the center of which is at 32° 12′ N. Lat., 64° 36′ W. Long.; standard lengths from 40 to 357 mm.

Specimens Previously Recorded.

About 110 adult and almost adult specimens in addition to about 675 larvae and young; surface to 3,281 fathoms; North Atlantic, Mediterranean, Indian Ocean and East Indies from the equator to about 40° N.; lengths from 9 to 1,445 mm.

Description of Transitional Adolescent.

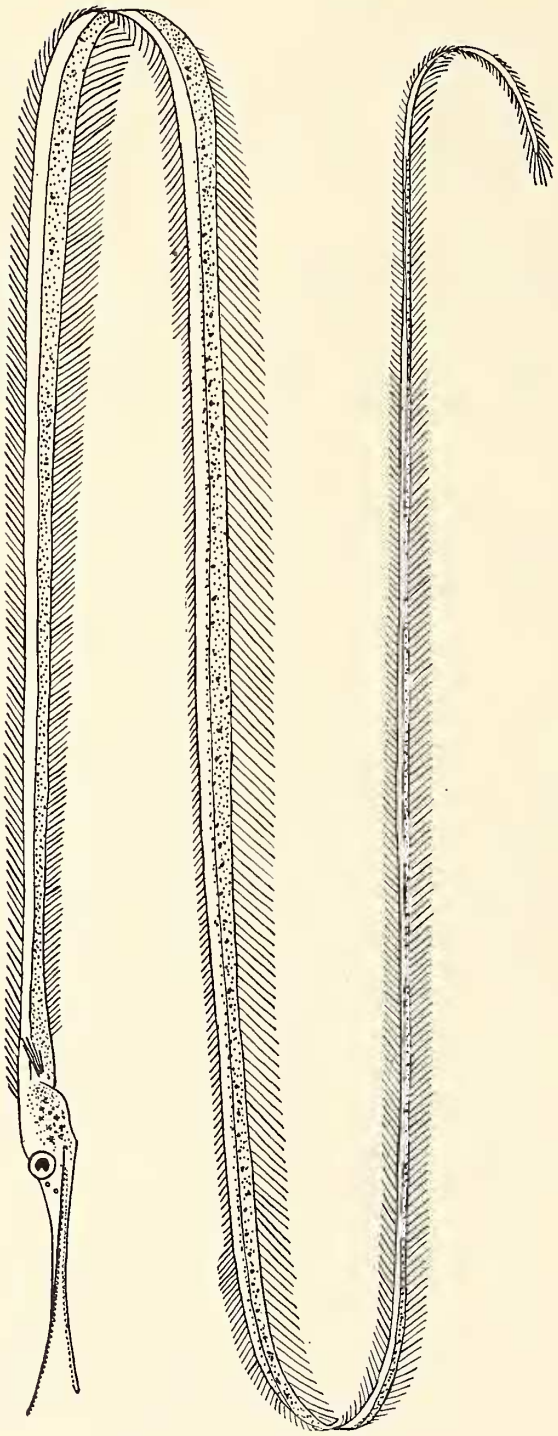
(Text-figs. 1, 2, 3C, 4G, 5G).

The following measurements and observations are taken from the three largest specimens in the Bermuda collection. All three have snout tips and caudal filaments complete and measure, respectively, 342, 342 and 357 mm. without caudal fin. The small amount of variation in the proportions, compared with the large amount in the series described by Roule and Bertin (1929) is notable. It will also be seen that the proportions do not differ markedly from those of the type, when allowance has been made both for the difference in age and for the possible damage to the snout tip in the type; the most reliable proportion, that of the eye in the postorbital distance, is seen to be very close in the two cases: 2.2 in the type, 2.4 to 2.9 in the present specimens, when these figures are compared with the great range of 1.4 to 5.3 in the series described by Roule and Bertin.

Color: (Fresh specimens). Pale tan to light brown (most advanced specimen), the ventral two-thirds of the body marked by dendritic chromatophores which are largest and densest on the abdomen. There are a few similar pigment spots on the proximal parts of the jaws and on the crown of the head, while the caudal filament is very sparsely pigmented, and that only on the ventral surface.

Proportions: Maximum depth (in advance of middle of body) in length 118 to 132 (.76 % to .85 %); depth of caudal filament at caudal base in eye diameted 6.9 to 8.1 (.0008 % to .0009 % of length); head in length 12.3 to 12.8 (7.8 % to 8.1 %); eye in head 12.2 to 13.2, in snout 8.4 to 9.3, in postorbital 2.4 to 2.9 (.62 % to .64 % of length); snout in head 1.4 to

[3] Specimens recorded (1931, pp. 73-74) as *Nemichthys infans, Tilurella Nemichthydis infantis* and *Serrivomer sector* examined by us in Museum of Comparative Zoology and found to be postlarval and adolescent *Nemichthys scolopaceus*, identifiable by their myomeral counts, pigmentation and rudimentary, but distinct, caudal filaments. The specimen described as *Nemichthys* sp. is a transitional adolescent *Serrivomer beanii*, identifiable by means of the teeth and the anterior prolongation of the branchiostegal rays.



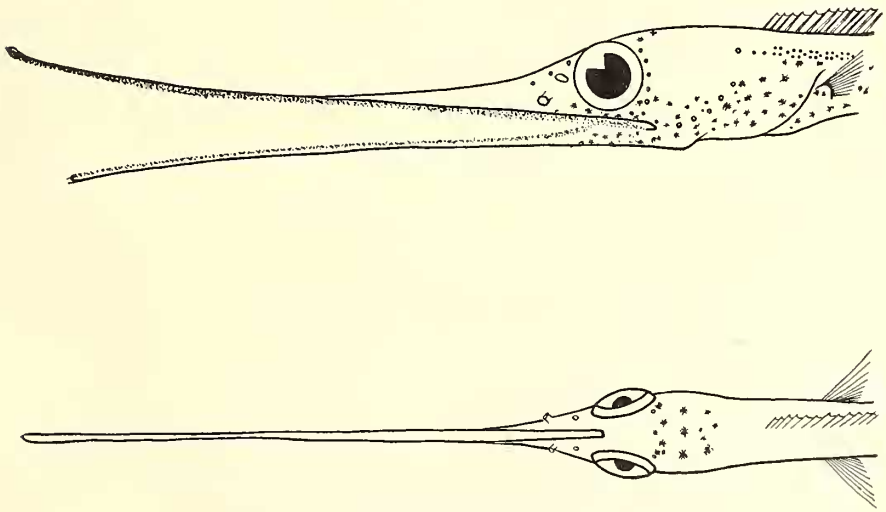
Text-figure 1.
Nemichthys scolopaceus. Standard length 342 mm. The complete numbers of fin rays are not indicated.

1.45 (5.4 % to 5.7 % of length); postorbital in head 4.6 to 5.2, in snout 3.2 to 3.7, (1.5 % to 1.8 % of length); interorbital in head 26.4 to 27, in eye 2 to 2.2, (.31 % to .34 % of length); maxillary extending slightly beyond posterior margin of orbit; tip of snout to tip of mandible in length of snout 15.4 to 17.1 (.33 % to .34 % of length; pectoral base to anal origin in postorbital length of head 1.6 to 1.8, (.94 % to .96 % of length); pectoral length in postorbital length 1.9 to 2.1; caudal filament in length 3.1 to 3.3 (30.4 % to 33 %).

Teeth: (Text-figs. 3C, 6, 7, 8). The maxillary holds a maximum of four rows of teeth irregularly arranged. On the ethmo-vomer there are, in the broadest portion, eight longitudinal rows set, not in quincunx, but in curving, transverse bands, the number of teeth in a longitudinal series being about 160. A secondary pattern formed by the same teeth is a sequence of V's, each apex being directed posteriorly. There is no trace, however, of a true quincunxial formation, such as has been described by previous authors reporting on *Nemichthys* and found by us in both *Avocettina* and *Labichthys*. On each mandibular ramus there are six longitudinal rows of teeth arranged in a strongly oblique series of transverse rows directed forwards and inwards, so that when the two rami are approximated a V-shaped pattern is formed like that of the ethmo-vomer; the curving, transverse bands characteristic of the latter bone, however, are not evident, although here also, the obliqueness of the transverse rows throws the teeth far out of quincunxial arrangement. Because, perhaps, of the youth of the specimens, the teeth are relatively shorter and blunter than in either *Avocettina* or *Labichthys*, while the terminal swellings of both jaws, although distinctly present, are not as well developed as in the other genera.

Fins: Pectoral rays 11, their length contained 1.9 to 2.1 times in post-orbital length, the first ray more strongly developed than the others, inserted at or slightly in front of the upper angle of the branchial cleft, below the second to sixth dorsal ray[4]. Dorsal rays about 405 to 450, about 100 of the median ones (from the 118th-148th ray to the 220th-252nd ray) being

[4] Instead of below the eleventh or twelfth dorsal ray, because of the immaturity of the specimens; as has been said, in larger specimens the dorsal originates even farther forward on the occiput.



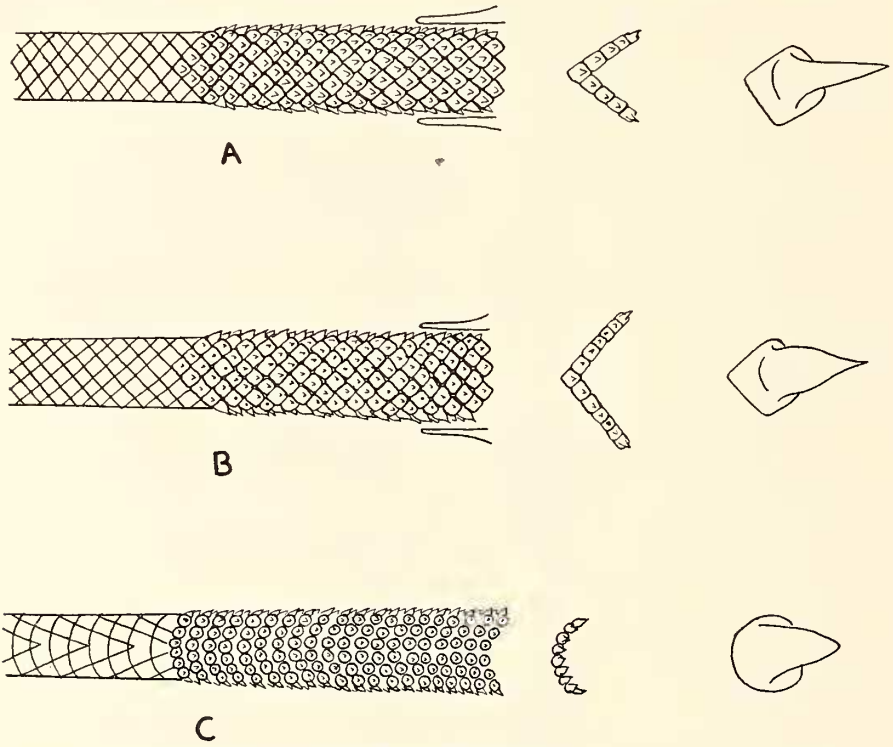
Text-figure 2.

Nemichthys scolopaceus. Head, lateral (upper) and dorsal (lower) views. Standard length 342 mm. (x 4.1).

reduced to spines by the breaking off of the delicate terminal portions of the rays; the last "spine" occurs about 15 rays in front of the origin of the caudal filament. Anal rays about 415 to 454, the longest in middle third of body, more than three times longer than dorsal rays and 25 % longer than maximum body depth; on the caudal filament both dorsal and anal rays are much shorter and more widely spaced than elsewhere, but along the entire length of the filament the rays, when unbroken, are 1.5 to 2 times the depth of the body at the corresponding point; in this caudal region, the anal rays are only slightly longer than the dorsal. Caudal rays five.

Vertebrae and Pores: There are about 450 vertebrae in a cleared and stained specimen 342 mm. in length, about 145 to 150 of them being included in the caudal filament. The characteristic pores, arranged quincunxially in three rows, are invisible in specimens examined in or out of the alcohol in which they have been preserved. After they have been soaked for half an hour or more in fresh water, however, the presence and pattern of the pores are clearly discernible under moderate magnification in at least the anterior part of the body; posteriorly they are so rudimentary that their numbers cannot be counted accurately.

Osteology: (Text-figs. 5-9). With the characteristics of the genus,



Text-figure 3.

Semi-diagrammatic representations of vomerine teeth in nemichthyid eels at broadest part of bone (near articulation with maxillary). The median vertical series represents single bands of teeth from the same sections of the vomer. Right-hand series shows single teeth, greatly enlarged. **A**, *Labichthys carinatus*, standard length 470 mm.; **B**, *Avocettina* sp., standard length 498 mm.; **C**, *Nemichthys scolopaceus*, standard length 357 mm.

which were derived from the cleared and stained 342 mm. specimen, one of the transitional adolescents under discussion. Immaturity is shown in the excessively slight degree of ossification, which is slight even for this delicately ossified family. The jaws alone show a moderate amount of stain, while the skull, opercular, hyoid and branchial apparatus show only a slight amount of bony matter and all the fins, their supports and the vertebral column are entirely unossified. Another indication of immaturity lies in the shape of the vertebrae, which are almost cylindrical. The simplicity of the tail, however (Text-fig. 9) is probably generic rather than juvenile.

Development.

(Text-figs. 4, 5).

Material: All stages, with the exception of the adult, are represented in the collection:

Larvae, 38 to 210 mm.: 10 specimens.

Post-larvae, 200 to 295 mm.: 13 specimens.

Adolescents, 240 to 312 mm.: 17 specimens.

Transitional adolescents, 300 to 360 mm.: 5 specimens.

Key to the Growth Stages: The following key will serve to distinguish the various growth stages, and to correlate them with the series described by Roule and Bertin (1929, pp. 67-96).

A. Body flattened laterally, its height much greater than its thickness and contained not more than 75 times in the length; translucent.

B. Depth in length 10-35; anal fin not in final position.

C. Larval fangs present; anal origin between 93rd and 257th myomeres, near end of body; no caudal filament. ..... *Larva* ("Leptocephale A").

CC. Larval fangs absent; anal origin between 256th and 7th myomeres, moving forward on body; caudal filament appearing. ..... *Post-larva* ("Tilurelle A," *partim.* and "Tilurelle B," *partim.*).

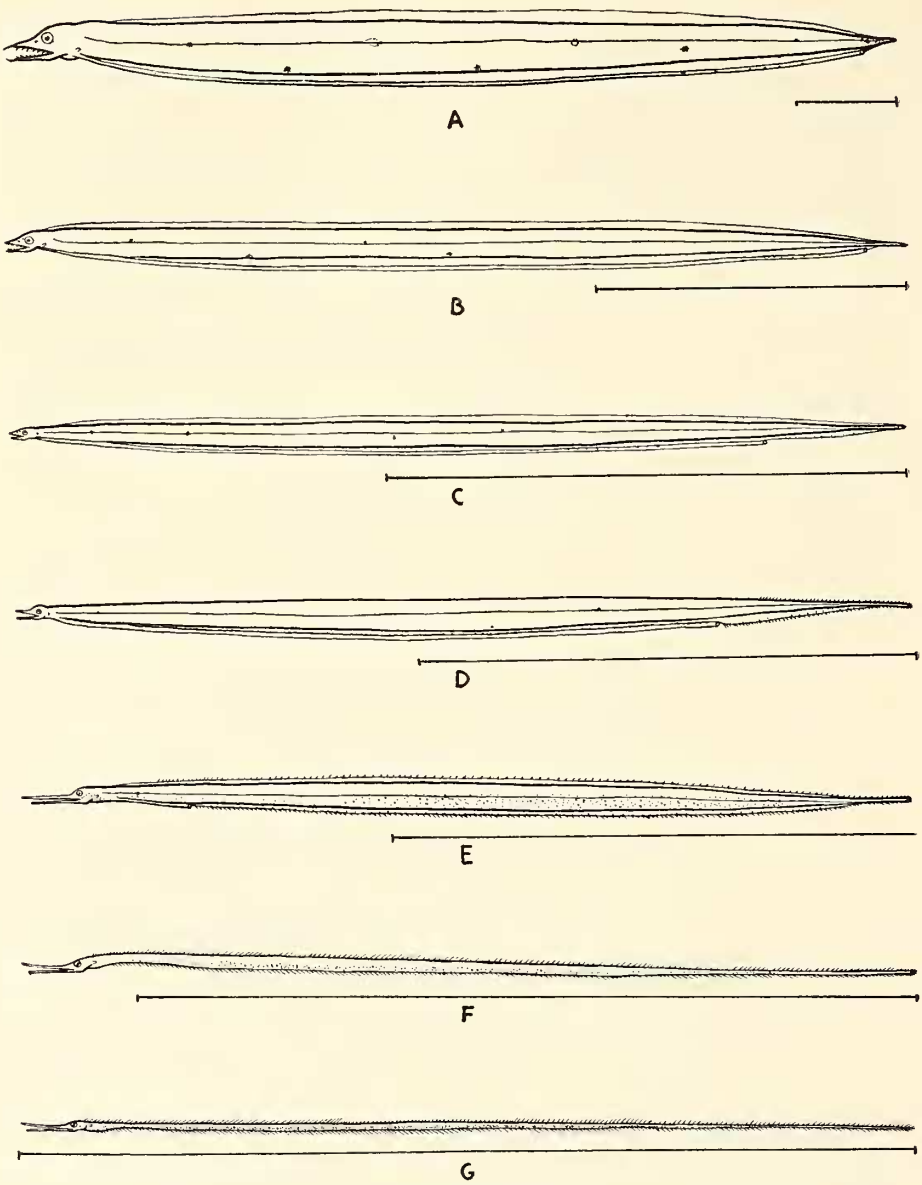
BB. Depth in length 60-75; anal fin in final position (at about 6th myomere) ..... *Adolescent* ("Jeunes *Nemichthys* transparents," *partim.*).

AA. Body rounded; slender (depth contained at least 120 times in the length; opaque.

D. Gonads developing; pigmentation, position of dorsal fins, ossification and dentition immature in earlier half of stage. ..... *Transitional Adolescent.*

E. Gonads mature ..... *Adult.*

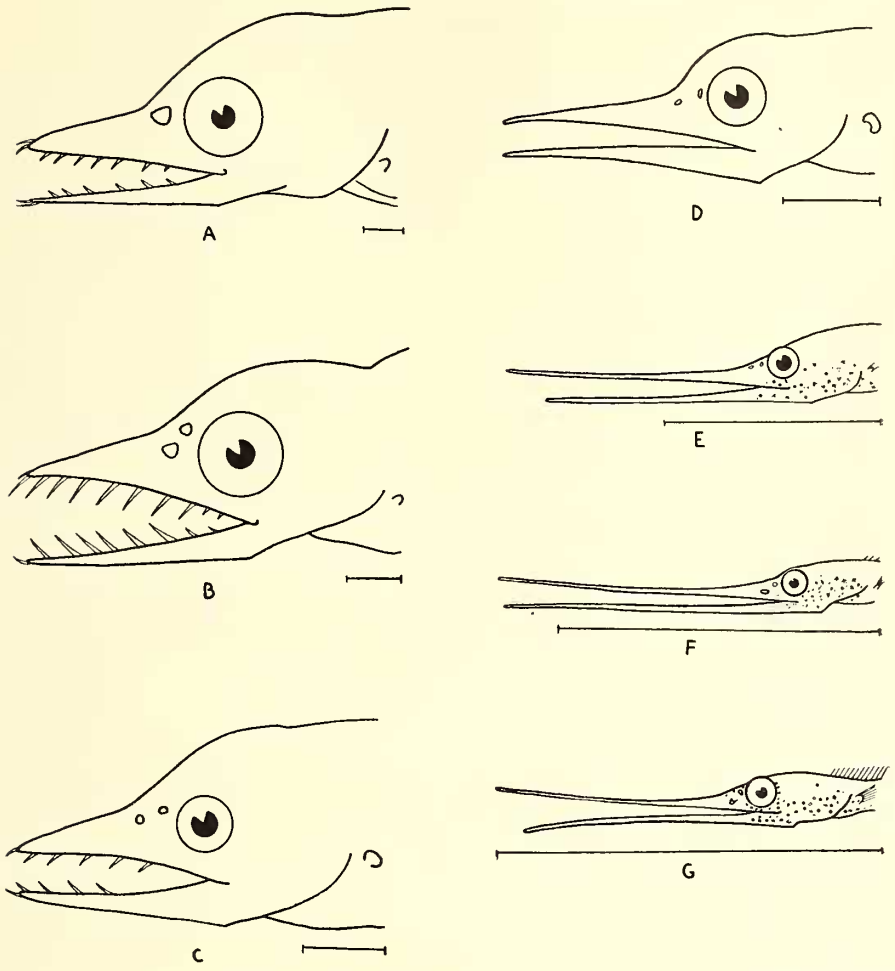
General Discussion: In 1929 Roule and Bertin (pp. 61 ff.) identified the larva of *Nemichthys* as a leptocephalus characterized chiefly by the presence of a great number of myomeres, posteriorly placed anus, mesenteric ligaments located in the same myomeres as in transformed specimens, long snout, and larval pigment spots on the medullary chord, along the intestine, and, post-anally, along the bases of the dorsal and anal fin. This general type they found to contain two forms; the first, designated as "Leptocephalus A," was characterized by the presence of four external, lateral pigment spots which always occurred at or near the 19th, 38th, 79th and 116th myomeres, by its smaller size range, and by the relatively small number of preanal myomeres. The second, designated as "Leptocephalus B," lacked all trace of the four lateral pigment spots, grew much larger before metamorphosing, and had a correspondingly large number of preanal myomeres.



Text-figure 4.

Nemichthys scolopaceus. **A** to **C**, incl., larvae, 40, 125 and 210 mm., respectively; **D** and **E**, post-larvae, 200 and 210 mm.; **F**, adolescent, 312 mm.; **G**, transitional adolescent, 357 mm.

It probably represented, Roule and Bertin decided, either another race of *Nemichthys scolopaceus* or a giant albino form of the same species, their identification resting largely on the positions of the mesenteric ligaments, the last one in each case being oblique and lying between the 83rd and 94th myomeres.



Text-figure 5.

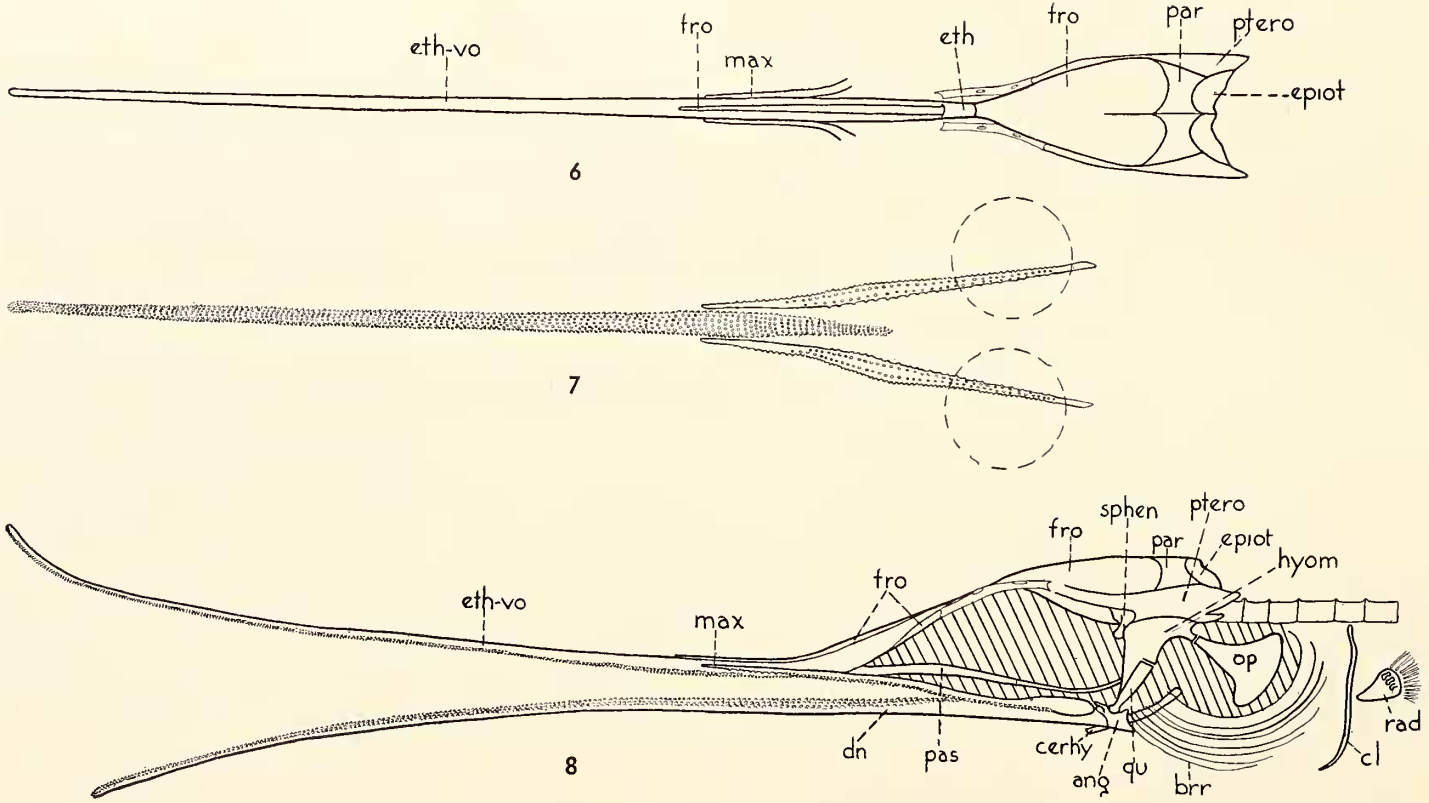
Nemichthys scolopaceus. **A** to **C**, incl., larvae, 40, 125 and 210 mm., respectively, in standard length; **D** and **E**, post-larvae, 200 and 210 mm.; **F**, adolescent, 312 mm.; **G**, transitional adolescent, 357 mm.

They further described six postlarvae ("Tilurelle A" and "Tilurelle B"), and three adolescents ("jeunes *Nemichthys* transparents") which show discrepancies both of size and coloration in the formation of the single series urged by these authors. All of these differences, however, they contend must be due to the variability of the species, and to the lack of sufficient material in the transforming, intermediate stages.

The following table will make these discrepancies clear:

Leptocephalus A, 664 specimens, length 9 to 253 mm., preanal myomeres 93 to 254.

Leptocephalus B, 26 specimens, length 32 to 359 mm., preanal myomeres 179 to 320.



Text-figures 6-8.

Nemichthys scolopaceus. **6.** Skull of transitional adolescent, dorsal view; standard length 342 mm. (x 7.1). **7.** Same, teeth of upper jaw and vomer, ventral view. (x 7.1). **8.** Same, bones of head, pectoral girdle and anterior part of vertebral column, lateral view. (x 7.1).

Tilurella A, 6 specimens, length 224 to 374 mm.; preanal myomeres 180 to 297.

Tilurella B, 4 specimens, length 230 to 286 mm.; preanal myomeres 70 to 39.

Young *Nemichthys*, transparent, 2 specimens, length 393, 413 mm.; preanal myomeres 6.

It will be seen that in Leptocephalus A the full range of preanal myomeres is from 93 to 257. The range for larger larvae (loc. cit., Table XV, p. 76), in which the anus has reached its most posterior position, is between 228 and 257 pre-anal myomeres; this stage being reached at 46 mm. In Leptocephalus B, on the other hand (loc. cit., Table XVI, p. 82), the full range is from 179 to 320 myomeres, the range for larger larvae being between 312 and 320 pre-anal myomeres, while this stage is not reached until 174 mm., the increase in pre-anal myomeres continuing until that point. Furthermore, the numbers in specimens of the same size—always one of the most important characters in the identification of larval eels—do not correspond in the two forms except in the smallest specimens: for example, the largest Leptocephalus A, at 253 mm., has 248 pre-anal myomeres, while two Leptocephalus B, of the corresponding lengths 231 mm. and 262 mm., have respectively 312 and 318 pre-anal myomeres.

Taking into account the minute specific differences between closely related leptocephali (e. g., between the larvae of *Anguilla anguilla* and of *Anguilla rostrata*) it seems clear that the differences between Leptocephali A and B of Roule and Bertin indicate that two entirely different species are involved, instead of merely two races, or normal and abnormal specimens. There seems no reason to suppose that either the general facies, the location of the last *bride mesentrique*, stressed by Roule and Bertin as constant in the two forms, or the fact that both "A" and "B" were often taken in the same net, prove that the forms are varieties of the same species; instead it seems much more probable that the form and position of the ligaments are family, or possibly, generic, characters.

The Tilurella A, ranging from 224 to 374 mm., also show discrepancies. The smallest is all of 135 mm. shorter than the largest larva of the Leptocephalus B type, while the following stage, Tilurella B, is represented by three specimens, all very short (230 to 286 mm.) compared with the longest Leptocephalus A and Tilurella A. Finally, the youngest adolescent specimens ("young transparent *Nemichthys*") mentioned, represent the earliest stage at which the dorsal and anal have reached their final positions and are, as the authors say, much farther advanced than the preceding stage, measuring 393 and 413 mm.—a length gap of more than 100 mm.

From a detailed study of the Bermuda material, we may confidently draw the following conclusions:

1. The careful description by Roule and Bertin of Leptocephalus A is perfectly applicable to our larvae, which make a continuous series, without either gaps or extensive overlappings in length, through post-larvae and adolescents to transitional adolescents of *Nemichthys*, presumably *N. scolopaceus*.

2. Roule and Bertin's Leptocephalus B belong to some other *Nemichthys*-like form, either *Cercomitus* or *Nematoprora*, or else to another species of *Nemichthys*, which is probably contained in the *Dana* collection—either the large-eyed or very small-eyed Atlantic form.

3. Their Tilurella A probably contains forms of both our species of *Nemichthys* (especially the smallest, in which Roule and Bertin were able to distinguish remains of the characteristic lateral chromatophores of Leptocephalus A, of which one or more of the possible four were distinguishable in every one of our post-larvae) and of the Leptocephalus B form, whatever that proves to be.

4. Doubtless some of the succeeding immature forms also belong to another species, either *Nemichthys* or a related genus, because of the following observations: Their smallest "adult" (i.e. transitional adolescent) measures only 215 mm. in length, while most of the deep-sea eels whose growth stages are known undergo the final steps of metamorphosis at about the same length within the species (*Serrivomer, Platuronides, Derichthys, Nessorhamphus*). In the second place, on p. 13 these authors state that the pigment of young *Nemichthys* develops tardily and, as in *Cercomitus* (Weber) appears first near the end of the caudal filament and in the region of the kidney; three of these forms they have figured on Pl. I, figs. 7, 8 and 9. They mention there are a few abnormal forms in which the pigment appears as "large black spots generally distributed on the ventral half of the body, as in their Pl. I, g. 10. Owing to the presence on three post-larvae in the present Bermuda collection of both typical larval lateral chromatophores and of the beginnings of general pigmentation in the form of superfical chromatophores on the ventral half of the body, it is certain that the "abnormal" specimen figured by them is in reality a true *Nemichthys* which has developed from a Leptocephalus A, since in adolescent specimens only slightly older, and with this same characteristic pigmentation, we have discovered the typical series of *Nemichthys* pores which Roule and Bertin found to appear only very tardily. The pores are, however, exceedingly difficult to see in these young specimens and not all of them are developed at this stage; sometimes they are distinguishable only after the alcoholic specimen has been soaked for an hour or two in fresh water; a moderately strong lens is, of course, necessary.

5. The following synonymy of *Nemichthys* leptocephali and immature forms may now be made:

Nemichthys scolopaceus:

Leptocephalus andreae Schmidt, 1912.
Leptocephalus canaricus Lea, 1913.
Tilurella nemichthydis scolopacei Roule, 1914, 1919.
Tilurella gaussiana Pappenheim, 1914.
Nemichthys scolopaceus, Leptocephalus A, Roule and Bertin, 1929.
Nemichthys scolopaceus, Tilurella A, Roule and Bertin, 1929 (*partim*).
Nemichthys scolopaceus, Tilurella B, Roule and Bertin, 1929 (*partim*).
Nemichthys scolopaceus, young transparent *Nemichthys*, Roule and Bertin, 1929 (*partim*).
Nemichthys infans, Borodin, 1931.
Tilurella Nemichthydis infantis, Borodin, 1931.
Serrivomer sector, Borodin, 1931.

Diagnostic Description of the Growth Stages: The characteristics of the growth stages are summarized below. For a thorough description of the larva, consult Roule and Bertin's description of Leptocephalus A (1929, pp. 68-81). For a description of the internal organs of subsequent stages, see the same source, pp. 86, 89.

Larva: (Text-figs. 4 A-C, 5 A-C). Pigment: This is found in four groups of chromatophores, the first two tending to disappear in older larvae, the last two becoming more noticeable with age: 1. A conspicuous chromatophore situated between the lateral mid-line and the ventral profile at or about the 19th, 38th, 79th and 116th myomeres. Of these, the first usually placed almost in the lateral mid-line, is the most constant; it has been found even in advanced post-larvae. 2. A series of internal spots on the spinal chord, which become more numerous with age; in small specimens there are usually three conspicuous ones, visible externally, through the skin,

in or near the 55th, 92nd and 145th myomeres. 3. A series of minute chromatophores on the dorsal surface of the intestine; in young specimens these are present on the posterior portion only, becoming more numerous and more extensive anteriorly with age. 4. A series of minute chromatophores on the dorsal and anal finfolds at the base of the developing dorsal and anal rays. These, too, increase in number with the development of the fins. In the very youngest larvae in the collection they are represented by less than half a dozen conspicuous spots posterior to the anus above and below the lateral mid-line.

Proportions: Depth (measured to exclude intestines and finfolds) 9 to 25 in length (11 % to 4 %). Head in length 8 to 40 (12.5 % to 2.5 %), largest in youngest specimens. Eye 4 to 5 in head, decreasing in size relative to the trunk with growth, almost round even in young specimens. Snout long, slender, longer than postorbital distance measured from posterior margin of eye to base of pectoral fin; profile of snout very broadly V-shaped, owing to a depression at level of nostrils; depth of head relative to its length almost constant throughout larval stage; supraorbital distance moderately great—not excessive as in serrivomerid larvae; highest point of head above posterior part of eye or just behind it; tips of jaws equal, or upper projecting very slightly; jaw angle under middle of eye in oldest specimens; this change in position is due partly to the relative decrease in the size of the eye and partly to an actual prolongation of the jaw.

Teeth: One or two pairs of long, slightly curved, fang-like larval teeth at tips of both jaws, each tooth being followed by four to nine similar ones, usually longer than the terminal fangs. The teeth are relatively longest in half-grown larvae (around 125 mm. in length); in fish of this length the teeth are all about of equal size (more than one-third longer than eye diameter), except for the first fangs and the last two pairs, which usually are somewhat smaller. As in other leptocephali, the larval teeth drop out gradually as the time for metamorphosis approaches, at a length of around 210 mm., until, in post-larvae, when the migration of the anal commences, they are completely lacking.

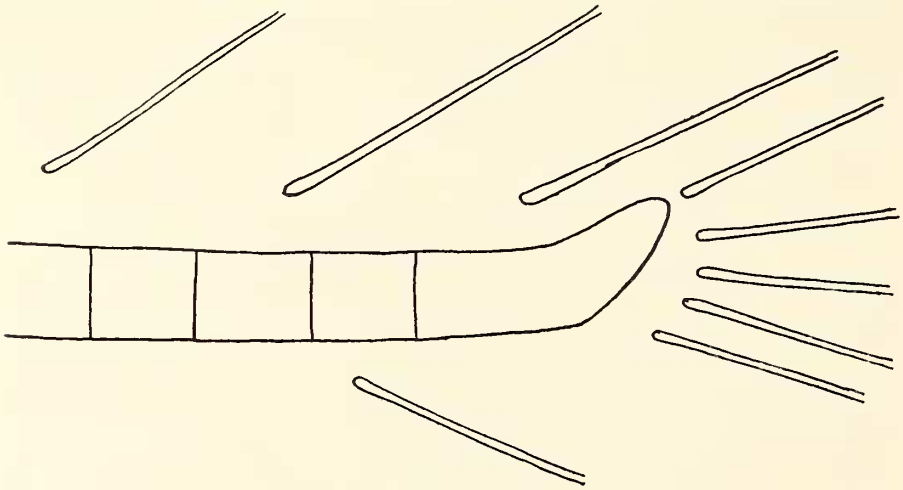
Fins: Pectoral small, fan-like, without true rays, typically larval; anal very short, occupying in young larvae the last one-twentieth of fish, in grown larvae, one-sixth (because of the increase in caudal myomeres alone, since the forward migration of the anus has not yet begun). Dorsal fins about equal in length to anal, sometimes extending slightly farther forward; rays of both fins only rudimentary in even the largest larvae. Dorsal and anal finfolds extending throughout length of body behind the nape, and behind the heart below the intestine, respectively. Caudal rays invisible in larvae, the finfolds dying out just before the very slender, pointed tip of the posterior end of the body.

Myomeral Count and Length Range: In the larva there is a total of about 100 to 450 myomeres, of which about 93 to 254 lie in front of the anus; the typical pre-anal count of about 230 to 254 is reached at about a length of around 65 mm. As has been said, the post-anal myomeres continue to increase throughout development. Roule and Bertin (loc. cit.) show that the extreme length range of the larva (Leptocephalus A) is from 9 to 253 mm.; our small series of 10 specimens range from 38 to 210 mm.

Post-larvae: (Text-figs. 4 D-E, 5 D-E). Examples of this stage in the present collection measure from 200 to 295 mm. As in other eels, during the post-larval and adolescent stages, the actual transformation from leptocephalus to anguilliform takes place. The post-larva differs from the larva most obviously in the loss of larval teeth, the gradual elongation and slenderizing of the snout, in the continued reduction of the relative size of the eye, and in the forward migration of the vertical fins, with a corresponding shortening and, later, the bending of the intestine. The individual finrays, though very short, become distinctly visible in this stage, the dorsal and

anal being still suspended above and below the body proper by finfolds, although the intestine is more closely approximated to the body than in the larva. In relative depth there is little change, although a slight increase in thickness takes place. The internal medullary and the intestinal pigment spots increase in number, while most of the external lateral characteristic pigment spots, near the 19th, 38th, 79th and 116 myomeres, are often lacking, although at least one, usually the first, remains in even the most advanced specimens. In these oldest post-larvae there are present, in addition to the larval spots, dendritic, adult chromatophores on the ventral half of the body. They extend from the postorbital region back as far as about the beginning of the last seventh of the body; the last seventh lacks all trace of pigment, proving that the *Dana* specimens in which pigment developed first in this position must have belonged to another species (see p. 361).

Adolescent: (Text-figs. 4 F, 5 F). Examples of this stage in the present collection range from 240 to 312 mm. The adolescent differs from the post-larva primarily in the fact that the anus, and with it the anal fin, has reached its final position immediately behind the base of the pectoral fin. It differs from the adolescent stage of other fishes in that the dorsal fin is not similarly completed: while it has already reached a position well in front of the pectoral, it continues to migrate slowly forward throughout not only adolescence, but transitional adolescence as well, until it reaches its characteristic position far forward on the occiput. The form of this adolescent stage is somewhat semi-leptocephalid (depth in length about 60 to 75, or 1.65 % to 1.34 %), although the fins are scarcely suspended above and below the profiles any more, and the body has thickened slightly. The depth is about half that found in post-larvae and twice that of transitional adolescents. The snout and jaw are typically nemichthyidiform, while the eye and postorbital distance are reduced to about their final relative small size in respect to the length of the head. The teeth are rudimentary. The caudal filament is distinguishable, though it is not as well marked as in the succeeding stage. The characteristic short, spinous finrays of the median part of the dorsal are not yet distinguishable. When the adolescents are soaked in water, typical series of *Nemichthys* pores become visible in the



Text-figure 9.

Nemichthys scolopaceus. Posterior part of vertebral column and base of caudal fin in transitional adolescent, standard length 342 mm. Greatly enlarged.

anterior part of the body. The larval pigment spots are absent, though the internal, medullary spots are still present, as well as those on the dorsal side of the now practically enclosed intestine. Adult pigment continues to develop on the lower half of the body, except on the end of the caudal filament.

Transitional Adolescent: (Text-figs. 4 G, 5 G). Examples of this stage in the present collection, ranging from 300 to 360 mm., have already been discussed, on pp. 353 to 357. In relation to development, it will be seen that transitional adolescents differ from members of the preceding stage chiefly in the completely anguilliform proportions of the body, in the development of the teeth, in the spiniform aspect of the median rays of the dorsal fin and the elongation of the other finrays, and, finally, in the increase in pigmentation (in this stage there appears for the first time a slight amount of pigment on the lower part of even the end of the caudal filament). The immaturity of the specimens is shown in the incomplete pigmentation, in the fact that the dorsal fin has not quite reached its final position on the occiput, in the small degree of ossification, and, finally, in the immaturity of the gonads. The number of vertebrae in the caudal filament probably continues to increase throughout life.

Ecology.

Seasonal Distribution: About half of the Bermuda specimens were taken in September, although the trawling season extended from April to September. These September examples included post-larvae, adolescents and transitional adolescents, but no larvae, the latter having all been taken earlier in the season.

Vertical Distribution: Except for two larvae, one at 50 fathoms and one at 400 fathoms, *Nemichthys* was taken only between 500 and 1,000 fathoms. Six-inch *nemichthyids*, however, were observed from the bathysphere at a depth of 75 fathoms.

Abundance: Next to *Serrivomer beanii* and *Eurypharynx pelecanoides*, *Nemichthys* is the most common deep-sea eel found in our Bermuda trawling area, 45 specimens having been taken in the nets. Among the Bermuda deep-sea fishes in general, however, the species is rare.

Sociability: Two *Nemichthys* came up in the same net on only four occasions. The three six-inch nemichthyids seen from the bathysphere were swimming in a group.

Food: Six of the larger specimens examined for food all had empty stomachs.

Viability: No *Nemichthys* has been taken alive.

Study Material.

The following list gives the catalogue number, net, depth in fathoms, date, length and growth stage of each specimen of *Nemichthys scolopaceus* taken by the Bermuda Oceanographic Expeditions. All were caught in the cylinder of water off the Bermuda coast described in *Zoologica*, Vol. XVI, No. 1, p. 5 and Vol. XX, No. 1, p. 1. "Trans. Adol." stands for "Transitional Adolescent."

No. 9,675; Net 49; 800 F.; Apr 29, 1929; 156 mm.; Larva.
No. 9,726; Net 56; 1,000 F.; April 30, 1929; 200 m.; Post-larva.
No. 11,015; Net 226; 700 F.; June 27, 1929; 104 mm.; Larva.
No. 11,074; Net 229; 1,000 F.; June 27, 1929; 45 mm.; Larva.
No. 11,353; Net 268; 700 F.; July 8, 1929; 242 mm.; Post-larva.
No. 11,692; Net 310; 600 F.; July 22, 1929; 230 mm.; Post-larva.

No. 12,438; Net 375; 800 F.; Aug. 15, 1929; 240 mm.; Post-larva.
No. 13,162; Net 430; 500 F.; Sept. 6, 1929; 202 mm.; Post-larva.
No. 13,513; Net 474; 700 F.; Sept. 9, 1929; ca. 300 mm.; Trans. Adol.
No. 13,644; Net 487; 800 F.; Sept. 21, 1929; ca. 240, ca. 285 mm.; Adolescents.
No. 13,709; Net 495; 800 F.; Sept. 23, 1929; 232, 294 mm.; Post-larva & Adolescent.
No. 13,754; Net 499; 800 F.; Sept. 24, 1929; 295 mm.; Adolescent.
No. 13,797; Net 505; 600 F.; Sept. 25, 1929; 357 mm.; Trans. Adol.
No. 14,850; Net 563; 600 F.; May 10, 1930; 38 mm.; Larva.
No. 15,302; Net 621; 600 F.; May 22, 1930; 40, 125 mm.; Larvae.
No. 15,459; Net 639; 700 F.; May 28, 1930; 312 mm.; Adolescent.
No. 17,153; Net 762; 1,000 F.; July 2, 1930; 245 mm.; Adolescent.
No. 16,957; Net 778; 700 F.; July 5, 1930; 245 mm.; Post-larva.
No. 16,955; Net 796; 1,000 F.; July 9, 1930; 210, 295 mm.; Larva, Post-larva.
No. 17,412; Net 810; 600 F.; Aug. 28, 1930; 253 mm.; Adolescent.
No. 17,413; Net 812; 600 F.; Aug. 28, 1930; 255 mm.; Adolescent.
No. 17,522; Net 824; 800 F.; Sept. 1, 1930; ca. 245 mm.; Adolescent.
No. 17,747; Net 834; 400 F.; Sept. 3, 1930; 226 mm.; Post-larva.
No. 17,786; Net 838; 600 F.; Sept. 3, 1930; 260 mm.; Adolescent.
No. 17,820; Net 842; 600 F.; Sept. 4, 1930; 305 mm.; Adolescent.
No. 18,004; Net 853; 500 F.; Sept. 6, 1930; 342 mm.; Trans. Adol.
No. 18,025; Net 855; 700 F.; Sept. 6, 1930; 220 mm.; Post-larva.
No. 18,066; Net 859; 500 F.; Sept. 8, 1930; 292 mm.; Adolescent.
No. 18,316; Net 867; 800 F.; Sept. 10, 1930; ca. 300 m.; Trans. Adol.
No. 18,451; Net 880; 500 F.; Sept. 12, 1930; 240 mm.; Adolescent.
No. 18,637; Net 893; 900 F.; Sept. 15, 1930; ca. 230 mm.; Post-larva.
No. 19,380; Net 946; 600 F.; Sept. 25, 1930; 235 mm.; Post-larva.
No. 19,477; Net 955; 1,000 F.; Sept. 28, 1930; 342 mm.; Trans. Adol.
No. 19,973; Net 967; 500 F.; Sept. 30, 1930; ca. 240 mm.; Adolescent.
No. 20,856; Net 1014; 400 F.; June 13, 1931; 85 mm.; Larva.
No. 21,002; Net 1041; 50 F.; June 26, 1931; 41 mm.; Larva.
No. 21,982; Net 1141; 800 F.; July 6, 1931; 184 mm.; Larva.
No. 22,310; Net 1161; 500 F.; Aug. 11, 1931; ca 250 mm.; Adolescent.
No. 22,750; Net 1195; 800 F.; Aug. 18, 1931; 210 mm.; Post-larva.
No. 23,293; Net 1283; 600 F.; Sept. 10, 1931; ca. 240 mm.; Adolescent.
No. 23,613; Net 1305; 500 F.; Sept. 15, 1931; 249 mm.; Adolescent.

Genus ***Avocettina*** Jordan and Davis, 1888.

Generic Characters: Nemichthyids with a single row of pores in the lateral line and the anus located far behind the level of pectoral base; caudal filament absent; teeth quincunxially arranged in straight rows; dorsal origin immediately behind level of pectoral base; dorsal rays in middle third of body neither short nor spinous.

Parietals separated by suture; supraoccipital absent; pterygoid vestigial, slender; mandible much shorter than ethmo-vomer; all opercular bones except preopercle present, although only feebly ossified; hyoid and branchial apparatus either moderately or very little ossified; a single hypohyal; ceratohyal short, distinct from epihyal from which arise the 7 to 12 branchiostegals, which are either short, or long and strongly curved; glossohyal, rudimentary or absent; urohyal slender, bifid basally; one or no basibranchial; both upper and lower coracoid present; four radials; vertebrae about 170 to 198; neuropophyses of caudal vertebrae spinous, arising from middle of centrum; three hypurals.

Discussion: Including Günther's description of the type species in 1878, five species of *Avocettina* have been described; namely, *A. infans* (Günther), 1878; *A. elongata* (Gill and Ryder), 1883; *A. gilli* (Bean), 1890; *A. bowersii* (Garman), 1899; and *A. exophthalma* Parr, 1932. Of these, *A. infans, A. elongata* and *A. exophthalma* were described from specimens taken in the Atlantic, while *A. gilli* and *A. bowersii* were from the eastern Pacific, having been caught off Alaska and Central America, respectively. Examples taken in the East Indies and Indian Ocean were referred by Brauer (1906) and Weber (1913) to the type species, *A. infans,* as were additional specimens recorded from the Atlantic by Jordon and Davis (1888), Norman (1930), Parr, with a query, (1932) and Roule (1933)[5]. We have examined at the Museum of Comparative Zoology the specimens referred by Borodin (1931) to *Nemichthys infans* and *Tilurella Nemichthydis infantis;* because of their characteristic myomeralcounts, larval pigment spots and rudimentary, but distinct, caudal filaments, we identify them as post-larval and adolescent examples of *Nemichthys scolopaceus.*

In the meantime Roule and Bertin (1929), having studied the 34 specimens taken by the *Dana* in the Atlantic and eastern Pacific, referred them all to *A. infans,* submitting the opinion that *A. infans, A. elongata, A. gilli,* and, more questionably, *A. bowersii,* were all probably synonymous. (*A. exophthalma* had not yet been described at the time of their work). Although settlement of the question will have to await a comparison of new material with the extensive *Dana* collection, as well as with the specimens from the East Indies and the Indian Ocean, nevertheless we have gathered evidence to show first, that *A. elongatus* is synonymous with *A. infans;* second, that the establishment of the validity of *A. gilli* must await a proper redefinition of *A. infans,* although the two are probably distinct; third, that *A. bowersii* is valid; and fourth, that probably at least one other species, as yet undescribed, has been already taken in the Atlantic. The single Bermuda specimen is included in the latter category.

In reaching these conclusions the following specimens in other collections have been examined:

1. *A. elongata* (Gill and Ryder), 1883: The unique specimen has been reexamined at the United States National Museum. Unfortunately, it is in very poor condition, with the upper jaw broken off short, the mandible missing entirely; the branchial and pectoral regions damaged; both pectoral fins, attached to a loose and twisted strip of abdominal skin, pulled far back out of place; and the first anal finrays uncountable. For these reasons, the only satisfactory proportion that could be taken was that of the interorbital breadth to the eye, in which it is contained about 1.9 times. A total of 198 pores was counted in the lateral line; supposing the usual number of about four pores to occur before the pectoral origin, a total of 194 pores are present on the trunk. The all important proportion of eye into postorbital distance cannot be determined because of the hopelessly damaged pectoral region; all that can be said is that the eye and postorbital both appear to be moderate—that the first is contained in the second, say, somewhere around three times. In spite of the somewhat large number of pores in the lateral line, it seems best, since the pores were not counted in the type specimen of *A. infans,* to emphasize the narrow interorbital and apparently moderate postorbital and eye, and synonymize *A. elongata* with *A. infans.*

2. *A. gilli* (Bean), 1890: The unique specimen of this Alaskan species also was examined at the United States National Museum. As in *A. elongata,* both jaws are broken off short, so that most measurements could not be taken. The eye is contained in the postorbital about 2.2 times, the interorbital in the eye more than twice. There are 177 or 178 pores in the

[5] When he found that the type specimen of *Gavialiceps tinayrei* Zugmayer (1914) was a typical *Avocettina.*

lateral line behind the pectoral origin and three in front of it. The anal originates at the vertical between the eighteenth and nineteenth pores behind the pectoral base. Accurate branchiostegal and finray counts cannot be secured without careful dissection or staining. With *A. infans* established as the variable species it is now understood to be, *A. gilli* may actually prove to be synonymous with it. It seems far more likely, however, that it will prove to be a distinct species, as is often found to be the case, with so-called cosmopolitan forms from the Pacific, when sufficient material becomes available. In any case, *A. gilli* is distinct both from the Atlantic *A. exophthalma*, characterized by the broad interorbital space, and from the small-eyed Pacific form, *A. bowersii*.

3. *A. bowersii* (Garman), 1899: The type specimen was examined at the Museum of Comparative Zoology, and Garman's original description and figure found to be accurate. Specimens taken by the Templeton Crocker Expedition of the New York Zoological Society off the coast of Lower California added as a further check to the unquestionable validity of this very distinct form with small eyes, many branchiostegals and few dorsal rays. Without doubt the *Dana* specimens from Panama recorded by Roule and Bertin belong also to this species (Roule and Bertin, 1929, p. 26, Table VI, nos. 6 to 15, 17-20, 24-27 and 29[6]).

In regard to the remaining species, *A. exophthalma* and *A. infans*, of which the types have not been examined, the following conclusions are drawn:

A. exophthalma Parr, 1932: This West Indian species with its wide interorbital space and large eye is almost certainly valid. It is likely that Specimen No. 3 of Roule and Bertin, and possibly also their young Specimen No. 30, belong to this species.

A. infans Günther, 1878: The type species, left to include the remaining known specimens, still embraces exceptionally diverse examples. Even when the Panamanian species of Roule and Bertin, and those mentioned above under *A. exophthalma*, are omitted from the list, there are still such wide variations in the proportions of remaining Atlantic specimens that it seems that more than one species must be involved. An example is the variability of the eye, which is contained in the postorbital distance 2.8 to 4.7 times. Although the latter figure is typical of the Pacific species, *A. bowersii*, still that form is distinguished by the fewer number of dorsal finrays (around 255 instead of around 340).

In the following study, the single Bermuda specimen is shown to differ from apparently typical *A. infans* in its greater interorbital width, larger eye, longer snout and smaller postorbital distance. For the following reasons, however, it is not designated as the type of a new species: First, it is intermediate in position between *A. infans* and *A. exophthalma*. Secondly, the type material of *A. infans* requires a reexamination, in the light of the material which has accumulated since the publication of the description. Thirdly, it is probable that Specimen No. 23 of Roule and Bertin from the West Indies belongs to the same species as the Bermuda specimen, if the latter does prove to be distinct. The same may be true of their Specimen No. 21, of one or both of Günther's smaller specimens and of Parr's (1932) damaged, 390 mm. example. This material should all be examined before a new species is established especially because, fourth and finally, the Bermuda specimen is in poor condition due to unforeseen decomposition in clearing and staining (after measurements were made), and it seems inadvisable to designate it as the type of a new species in a genus already so confused. It is hoped that the following description, which is

[6] No. 28 from Panama does not agree, as Parr has already pointed out (1932, pp. 11-12). The localities of the numbered *Dana* specimens have been determined from a comparison of their lengths with specimens of corresponding lengths tabulated geographically in Roule and Bertin, 1929, p. 27, Table VII.

complete save for the dorsal fin count, will leave no doubt as to the specimen's proper taxonomic position when more material is gathered and the question settled.

Avocettina sp.

Specimen Taken by the Bermuda Oceanographic Expeditions.

1 specimen; July 2, 1930; 1,000 fathoms; from a cylinder of water 8 miles in diameter (5 to 13 miles south of Nonsuch Island, Bermuda), the center of which is at 32° 12′ N. Lat., 64° 36′ W. Long.; standard length 498 mm.

Description.

(Text-figs. 10, 11).

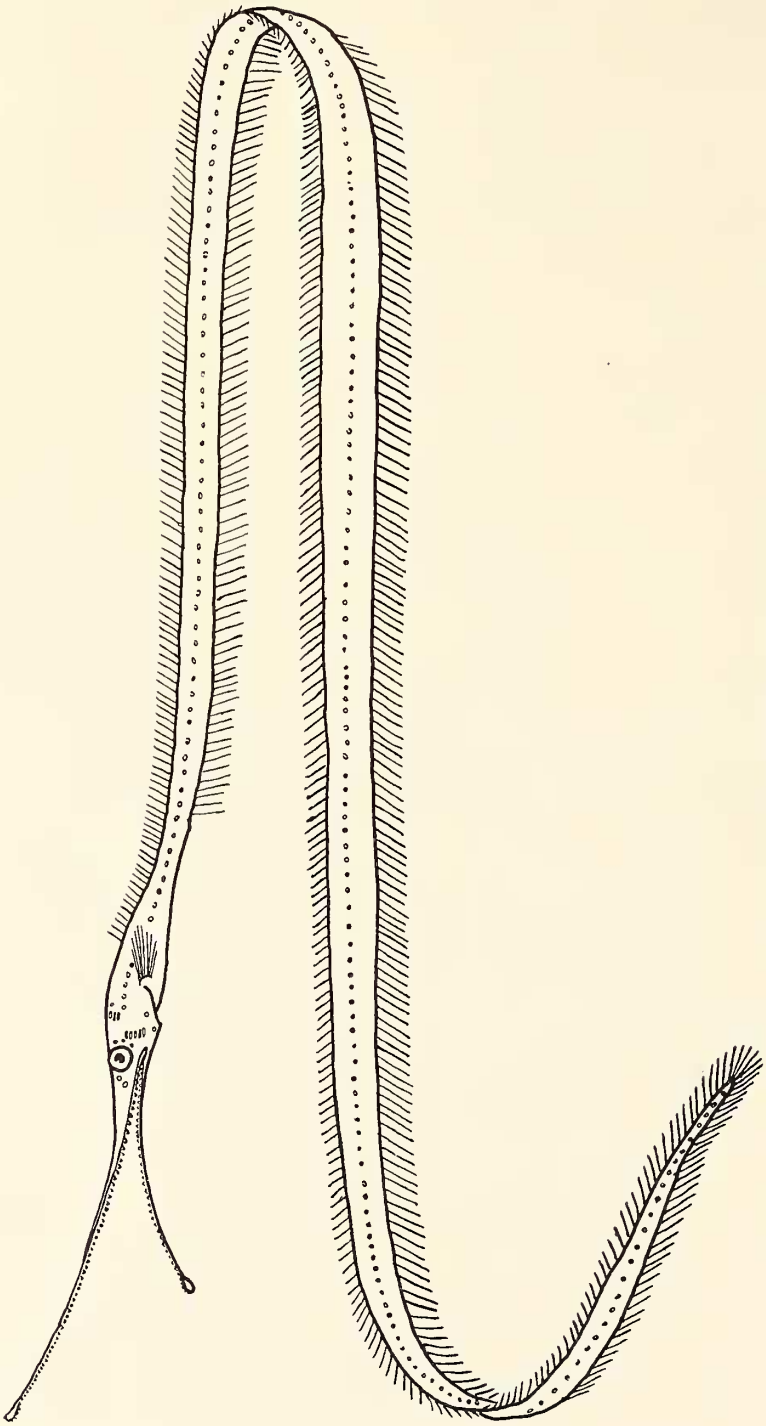
(With comparative notes on specimens of *Avocettina bowersii* from the Pacific).

Color of Fresh Specimen: Dark brown, spotted ventrally with black.

Measurements and Proportions: Length 498 mm.; depth at pectoral base 7 mm. (in length 71.1 or 1.4 %); maximum depth (187 mm. in front of end of tail) 8 mm. (in length 62.3 or 1.6 %); minimum depth (30 mm. behind eye) 3.5 mm. (in length 142 or 0.7 %); head 63 mm. (in length 7.9 or 12.7 %); eye 3.66 mm. (in head 17.2, in postorbital 2.4, 0.74 % of length); snout 53.4 mm. (in head 1.2, 10.7 % of length); postorbital 8.6 mm. (in head 7.3, in snout 6.2, 1.73 % of length); interorbital 3.2 mm. (in head 19.7, in eye 1.1, 0.64 % of length); tip of snout to posterior end of maxillary 57.5 mm., extending slightly behind posterior margin of orbit; tip of mandible to angle of jaw 36.5 mm.; tip of snout to tip of mandible 15.7 mm. (in snout 3.4, 3.2 % of length); pectoral base to dorsal origin 5.2 mm. (in postorbital 1.7, 1.04 % of length); pectoral base to anal origin 43 mm. (5 times postorbital length of head, 8.6 % of length); pectoral length 9 mm.; caudal length 4.4 mm.

Teeth: (Text-figs. 3B, 12, 13, 14). The entire inner face of the flattened maxillary is covered with minute, backwardly directed teeth arranged irregularly in quincunx: along the slender anterior edge they form a single row; farther back, at the widest portion of the bone, there are 12 rows, while at the posterior end the number is reduced to six. The teeth on the mandible and ethmo-vomer are larger and directed more sharply backward than those on the maxillary. The upper surface of the mandible and the lower surface of the ethmo-vomer are both strongly arched, their reverse sides being flattened; the teeth on both bones cover the entire surface of the arch, extending halfway or more to the border of the flattened surface, except near the anterior end. Here, where the bones become very slender and laterally compressed, the teeth are reduced to a single row along the apex. Beyond this point are the well-defined, swollen terminal knobs, both the upper and lower being well provided with irregularly set teeth. Both in this species and in a 431 mm. specimen of *Avocettina bowersii* taken off Lower California (see p. 374, Specimen No. 24,795, for data) there are at the broadest portion of the bones 13 rows of teeth, arranged in perfect quincunx, on both the ethmo-vomer and the mandible. In the present specimen about 260 teeth are placed in the mid-line of the ethmo-vomer posterior to the terminal knob.

Fins: Pectoral rays 17, originating under third to fourth lateral line pore, the first ray expanded and strongly developed, the second similar, but strengthened to a lesser degree. Dorsal and anal rays damaged, not countable; dorsal origin behind pectoral base above sixth lateral line pore

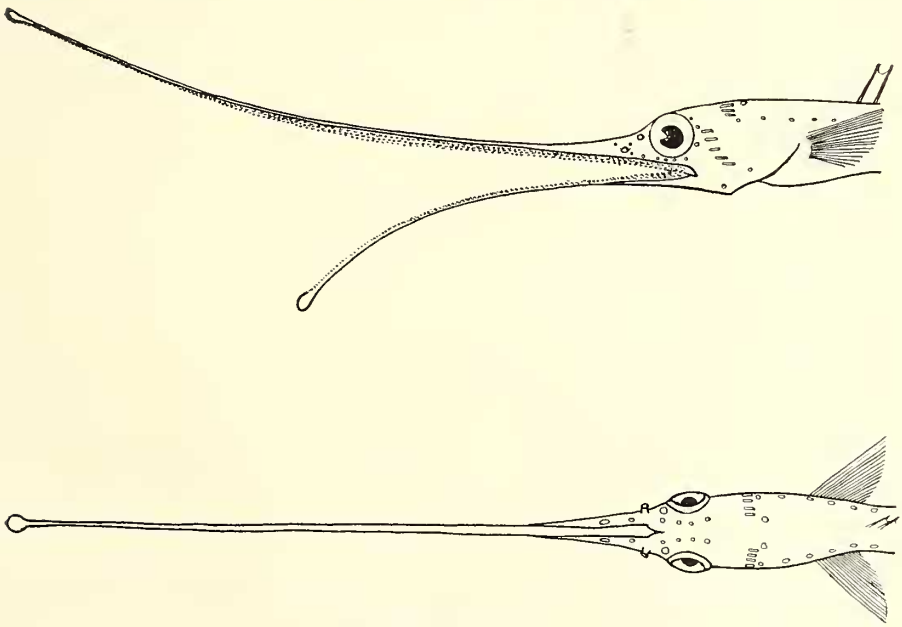


Text-figure 10.
Avocettina sp. Standard length 498 mm. The complete numbers of fin rays are not indicated.

(third behind pectoral origin); anal origin under twenty-third lateral line pore (twentieth behind pectoral origin). Except for the first, short rays, the dorsal and anal rays both are longest in the anterior two-thirds of the body; anal rays about twice as long as dorsal, more than half maximum depth of body at that point. Caudal rays five.

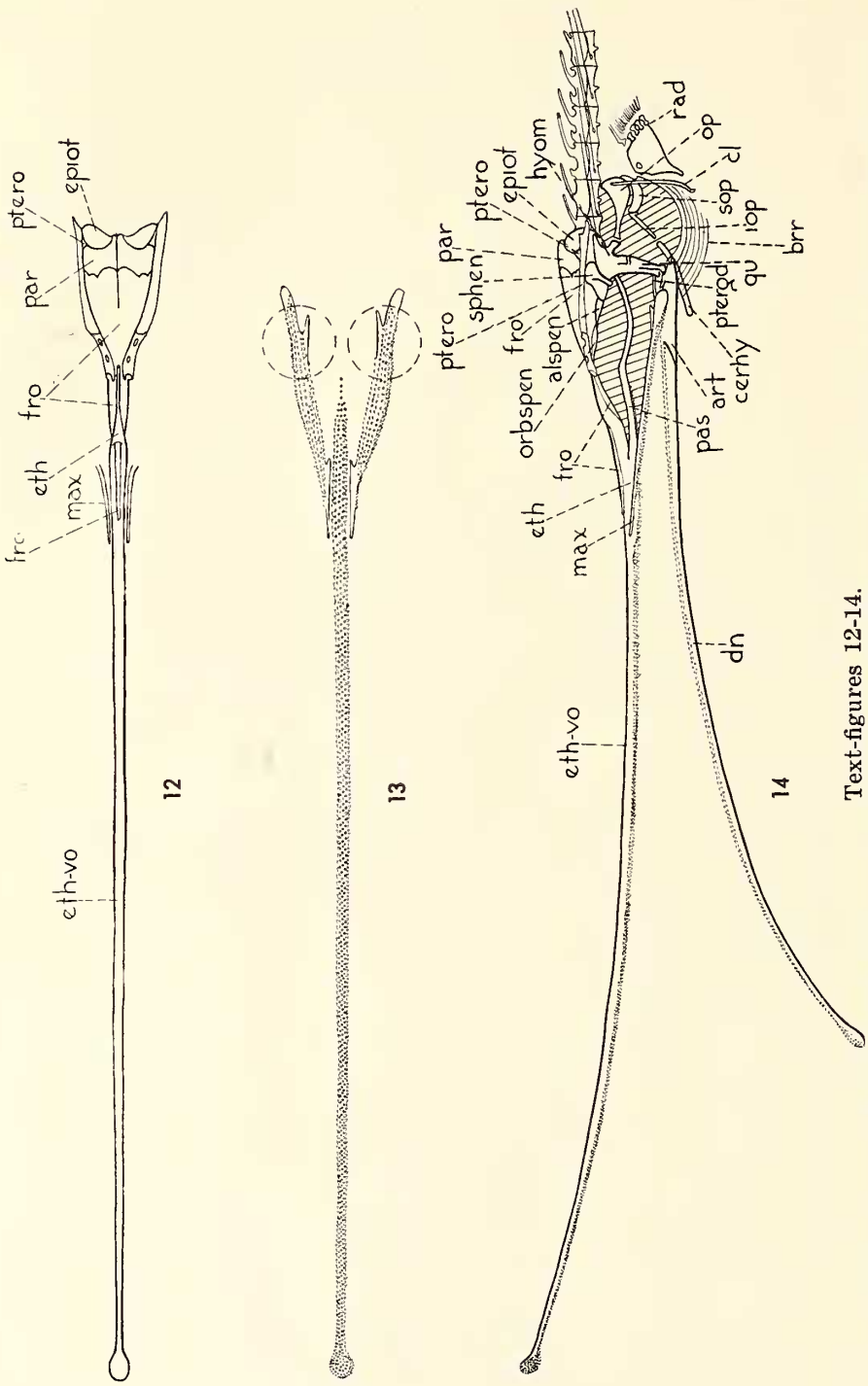
Pores and Vertebrae: There were 195 pores in the lateral line, the first three occurring in front of the pectoral base. Because of the decomposition of the trunk during clearing, it is impossible to count the vertebrae; however, in the specimen of *Avocettina bowersii* mentioned above, the number of vertebrae exactly coincided with the total number of lateral line pores (175), so that in all probability equally similar results would have been obtained could the vertebral count have been obtained for the Bermuda specimen.

Osteology: (Text-figs. 12-16). With the characteristics of the genus. Hyoid apparatus very feebly ossified; seven short branchiostegals, corresponding to the lack of space between pectoral and opercle—i.e., the shortness of the postorbital region. (The specimen described by Trewavas (1932, p. 650) had the branchiostegals "much bowed," while those of *Avocettina bowersii* are similarly bowed, and very long in addition, corresponding to the more spacious postorbital region). Branchial apparatus entirely cartilaginous except for moderately well ossified pharyngobranchials. (In *Avocettina bowersii* the entire hyoid and branchial apparatus, though composed of delicately slender bones, are well ossified). Cleithrum at level of second vertebra, first pectoral ray at end of third. (In *Avocettina bowersii* the cleithrum is more slender, and falls at the level of the fifth vertebra, while the first pectoral ray is underneath the sixth). The vertebral column is almost entirely unossified, although the dorsal and anal rays, the pectoral fin, and all fin supports show moderate amounts of ossification. This is all in contrast to the skeleton of *Avocettina bowersii*, which is relatively well



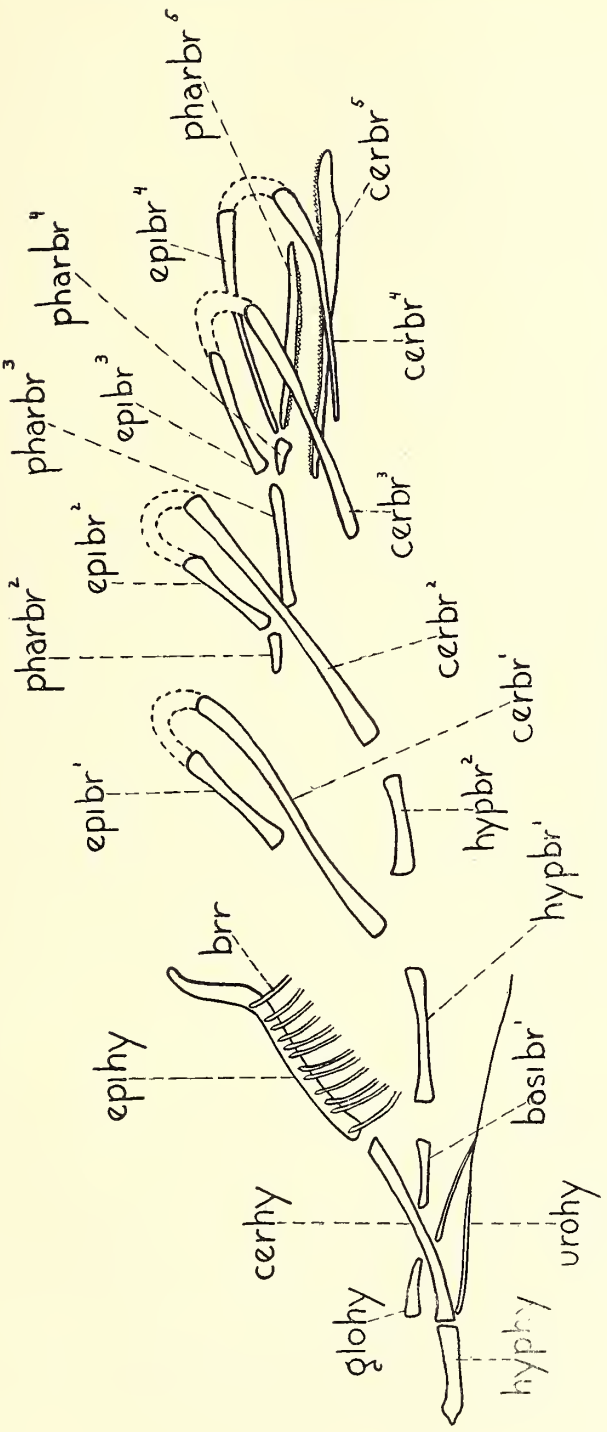
Text-figure 11.

Avocettina sp. Head, lateral (upper) and dorsal (lower) views. Standard length 498 mm. (x 1.6).



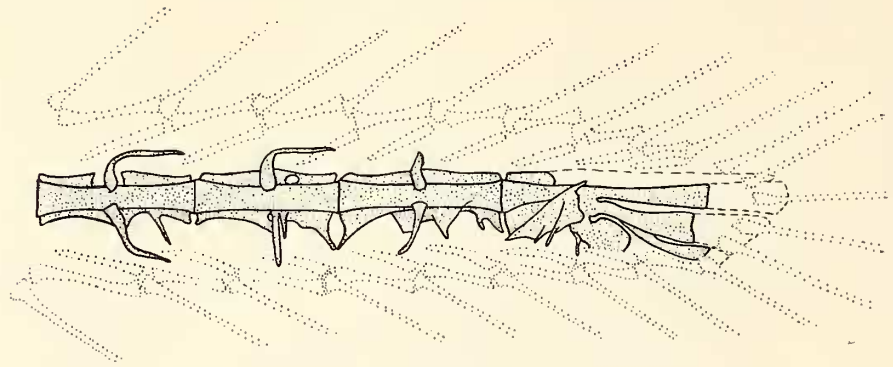
Text-figures 12-14.

Avocettina sp. **12.** Skull of adult, dorsal view; standard length 498 mm. (x 2.6). **13.** Same, teeth of upper jaw and vomer, ventral view. (x 2.6). **14.** Same, bones of head, pectoral girdle and anterior part of vertebral column, lateral view. (x 2.6).



Text-figure 15.

Avocettina sp. Hyoid and branchial apparatus of adult, standard length 498 mm. (x 18.4).



Text-figure 16.

Avocettina bowersii. Posterior part of vertebral column and base of caudal fin in adult, standard length 431 mm. (x 17.5).

ossified throughout. Since the tail of the Bermuda specimen of *Avocettina* sp. disintegrated during the clearing and staining process, a figure of the caudal vertebrae of *Avocettina bowersii* is included in this paper (Text-fig. 16). The tails of two specimens of this species were examined—that of the one referred to above, and another, slightly smaller example (for data see below, Specimen No. 25,783), and were found to be practically identical, both in the strong degree of ossification of the vertebrae, finrays and supports and in structure. The characteristic elements of the latter are the three hypurals and the irregular flange of bone directed forward and downward which arises on each side of the last vertebra. The neural spines arise from the center of the centrum, not from the posterior portions, as Trewavas states is the case in *Nematoprora polygonifera* (loc. cit. p. 649).

Coelomic Organs: With the characteristics of the family. All of the internal organs with the exception of the speckled kidney are entirely unpigmented. The kidney, commencing 12 mm. behind the pectoral base, is traceable to within 35 mm. of the tip of the tail. The specimen is a female, with scarcely developed ovaries. Starting at the level of the anus, they are visible as slender strands of tissue until their termination 212 mm. behind the pectoral base.

Study Material.

1. A single specimen of *Avocettina* sp. taken by the Bermuda Oceanographic Expedition, in the cylinder of water off the Bermuda coast described in *Zoologica*, Vol. XVI, No. 1, p. 5:

No. 16,667; Net 762; 1000 F.; July 2, 1930; 498 mm.; Adult.

2. Specimens of *Avocettina bowersii* taken by the Templeton Crocker Expedition to the Gulf of California and Clarion Island (see *Zoologica*, Vol. XXII, No. 2, pp. 33-46; "The Templeton Crocker Expedition. II. Introduction, Itinerary, List of Stations, Nets and Dredges," by William Beebe):

a. No. 24,795; Sta. 134 T-2; 450 F.; March 30, 1936; 431 mm.; Adult; from 12 m. SW. of Cape Falso, Lower California.

b. No. 25,783; Sta. 165 T-2; 400 F.; May 17, 1936; 410 mm.; Adult; from 145 m. N. of Clarion Island, Revilla Gigedos.

Genus ***Labichthys*** Gill and Ryder, 1883.

Generic Characters: Nemichthyids with a single row of pores in the lateral line and the anus close behind level of pectoral base; caudal filament absent; teeth alternating in straight rows; dorsal origin slightly in advance of level of pectoral base; dorsal rays in middle third of body not short or spinous.

Parietals separated by suture; supraoccipital present; pterygoid vestigial, slender; mandible slightly shorter than ethmo-vomer; all opercular bones except preopercle present, but only feebly ossified; hyoid and branchial apparatus scarcely ossified; a single hypohyal; ceratohyal short, distinct from epihyal from which arise the eight strongly curved branchiostegals; basibranchials apparently absent; one coracoid; four radials; vertebrae about 175 to 180.

Labichthys, with a supraoccipital present, pterygoid vestigial but apparent and an opercular apparatus relatively well developed is, in these important characters at any rate, the least specialized of all the Nemichthyidae (with the possible exception of *Cercomitus*, which has not yet been studied osteologically).

Discussion: Only a single species, *L. carinatus* Gill and Ryder, 1883, has been described which belongs in this genus. *L. elongatus* Gill and Ryder, 1883, *L. gilli* Bean, 1890, and *L. bowersii* Garman, 1899, have, since their description, all been properly referred to *Avocettina*.

The three specimens of *L. carinatus* which have been previously taken are, respectively, the type and the two examples recorded by Parr (1932 and 1934). The present specimens agree well with the recorded measurements.

Labichthys carinatus Gill & Ryder, 1883.

Specimens Taken by the Bermuda Oceanographic Expeditions.

3 specimens; April to August, 1929 to 1931; 500 to 1,000 fathoms; from a cylinder of water 8 miles in diameter (5 to 13 miles south of Nonsuch Island, Bermuda), the center of which is at 32° 12′ N. Lat., 64° 36′ W. Long.; standard lengths 200+ to 470 mm.

Specimens Previously Recorded.

3 specimens; about 450 to 906 fathoms; western North Atlantic; recorded lengths 447 mm. and 605 mm.

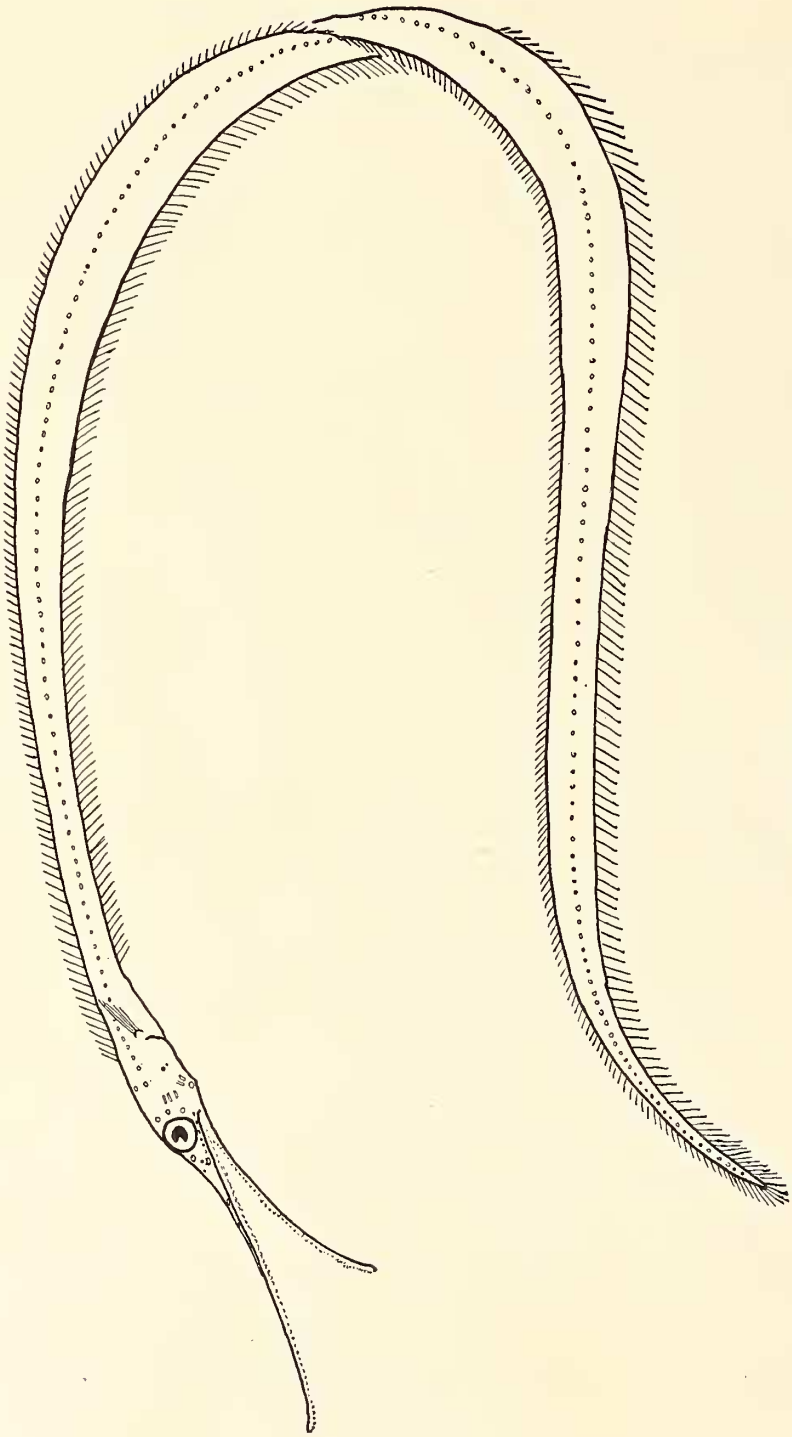
Description of Adult.

(Text-figs. 17, 18).

(From the two largest Bermuda specimens, 352 and 470 mm. in length; the smallest, 200+ mm. specimen was too badly damaged for exact measurements and counts to be made).

Color of Recently Preserved Specimens: Plain dark brown.

Proportions: Maximum depth (near middle of body) in length 36 to 41.5 (2.4 % to 2.8 %); head in length 7 to 7.6 (13.2 % to 14 %); eye in head 12.4 to 12.8, in postorbital 2.3 to 2.6, (1.06 % to 1.1 % of length); snout in head 1.36 to 1.39 (9.7 % to 10.3 % of length); postorbital in head 4.1 to 5, in snout 3.6 to 4, (2.5 % to 2.8 % of length); interorbital in head 15.6 to 16.5, in eye 1.2 to 1.3, (0.8 % to 0.9 % of length); maxillary extending slightly beyond posterior margin of orbit; tip of snout to tip



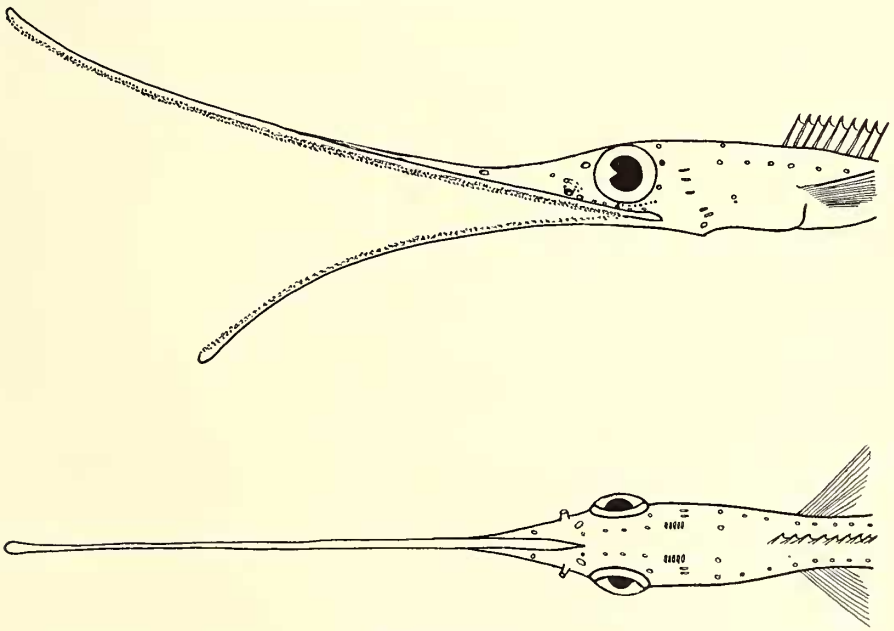
Text-figure 17.
Labichthys carinatus. Standard length 470 mm. The complete numbers of fin rays are not indicated.

of mandible in length of snout 3.1 to 3.2 (3 % to 3.3 % of length); pectoral base to anal origin in postorbital length 1.3 to 1.4 (2 % of length).

Teeth: (Text-figs. 3A, 19, 20, 21). The dentition of *Labichthys* agrees closely with that of *Avocettina* (see page 369) except in the following details: there are only 9, not 13, rows of teeth both on the mandible and on the ethmo-vomer; the teeth of the latter bones are more slender than those either on the mandible or than those of *Avocettina;* finally, there is a total of only about 220 teeth in a straight line along the mid-line of the ethmo-vomer, instead of about 260, as in both *Avocettina* sp. and *A. bowersii.* Both jaws are furnished with terminal knobs, but the latter are smaller and more elongate, less spherical than in *Avocettina.*

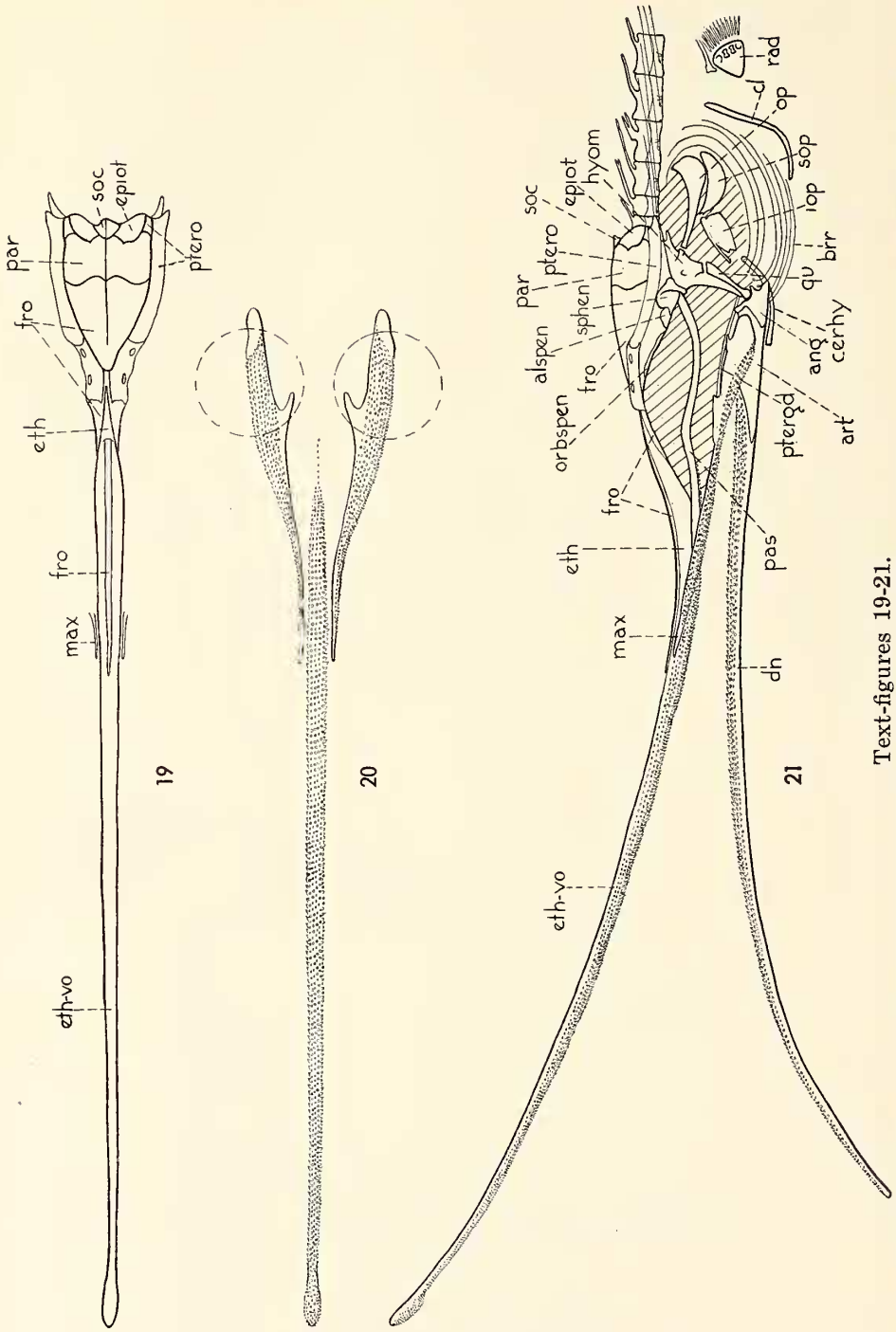
Fins: Pectoral rays 13, originating under second to fourth dorsal ray and beneath third to seventh lateral line pore, the dorsal origin, therefore, being slightly in front of pectoral base. (In the type specimen, which was reexamined by us at the United States National Museum, the pectoral commences under the sixth pore). First pectoral ray expanded and thickened, second and third similar, but smaller. Dorsal and anal rays so damaged that their numbers cannot be counted or their relative lengths determined, except that the anal rays are, as usual in this group, considerably longer than the dorsal rays. The anal originates under the eleventh to thirteenth dorsal ray and the seventh to twelfth lateral line pore. (In the type the anal commences under the space between the ninth and tenth pores; in the type description a count of 268 dorsal and 287 anal rays is given).

Pores and Vertebrae: There are 176 and 179 pores in the lateral line, the first three to six occurring in front of the pectoral base. An equal number of vertebrae was found in the specimen which was cleared and stained. (In the type there are 180 pores).



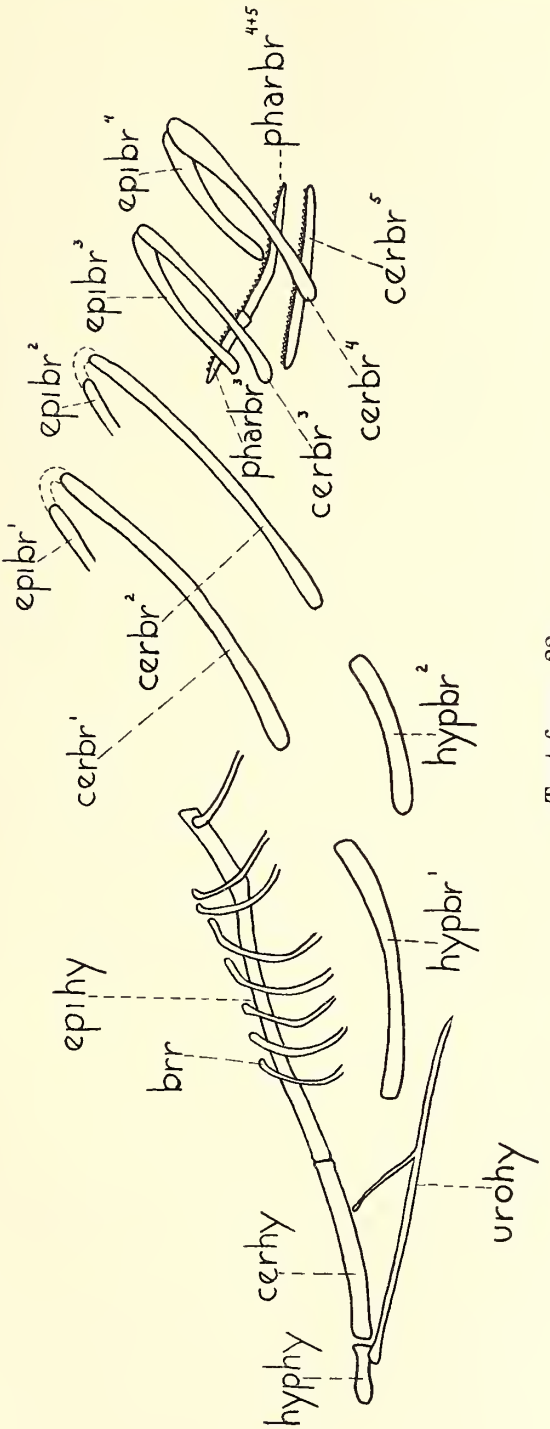
Text-figure 18.

Labichthys carinatus. Head, lateral (upper) and dorsal (lower) views. Standard length 470 mm. (x 1.8).



Text-figures 19-21.

Labichthys carinatus. **19.** Skull of adult, dorsal view; standard length 470 mm. (x 3.1). **20.** Same, teeth of upper jaw and vomer, ventral view. (x 3.1). **21.** Same, bones of head, pectoral girdle and anterior part of vertebral column, lateral view. (x 3.1).



Text-figure 22.

Labichthys carinatus. Hyoid and branchial apparatus of adult, standard length 470 mm. (x 16.4).

Osteology: (Text-figs. 19-22). With the characteristics of the genus. Unfortunately the entire trunk, including the vertebral column, fins and tail, fell to pieces during the staining process, so that no details can be given of this region except that the vertebral column appeared to be fairly well ossified and the dorsal and anal finrays strongly so. The jaws and pectoral fin were likewise strongly stained, but the rest of the skull as well as the hyoid and branchial apparatus showed exceedingly little ossification.

Discussion: The present specimens agree well with the type specimen. With the percentages given by Parr (1932, p. 16) for a 605 mm. specimen, our smaller examples differ in having relatively slightly shorter snouts (9.7 % to 10.3 %, not 11.9 %, of length) and smaller eyes (1.06 % to 1.1 %, not 1.16 %, of length). The postorbital length of the head is identical, relative to the length, in all three specimens, although the distance from pectoral base to anal origin is again slightly smaller in the present specimens (2 % instead of 2.8 % of length). Another slight difference is that in our specimens the eye and the dorsal rim of the orbit do not protrude so far above the line of the snout and skull, as depicted in Parr's Fig. 9 (1932, p. 18). Finally, the interorbital width in our specimens is greater than in Parr's (0.8 % to 0.9 %, instead of 0.73 %, of length).

The rostral ridges which, by their prominence in the shrunken type, gave the species its name, are not, as Parr has pointed out, very noticeable in fresh specimens. From the present drawing of the skull (Fig. 19) it will be seen that the ridges are merely the postero-lateral edges of the ethomo-vomer which fold up over the anterior end of the frontal. The same general effect is found in both *Avocettina* and *Nemichthys*.

Study Material.

The following list gives the catalogue number, depth in fathoms, date of capture, length and growth stage of each specimen of *Labichthys carinatus* taken by the Bermuda Oceanographic Expeditions. All were caught in the cylinder of water off the Bermuda coast described in *Zoologica*, Vol. XVI, No. 1, p. 5.

No. 9,704; Net 36; 900 fathoms; April 24, 1929; 352 mm.; Adult.
No. 16,459; Net 756; 1,000 fathoms; July 1, 1930; 470 mm.; Adult.
No. 22,309; Net 1143; 500 fathoms; Aug. 7, 1931; 200+ mm.; Adult.

Bibliography.

Alcock, A. W.:

1892. Natural History Notes from H. M. S. "Investigator". *Ann. Mag. Nat. Hist.* Ser. VI, Vol. X.

Ariola, V.:

1904a. Pesci Nuovi o Rari per il Golfo di Genova. *Ann. Mus. Civico Storia Natur., Genova*, Vol. LI.

1904b. Due Pesci Abissali del Mediterraneo. *Bull. Aquicoltura Lombarda, Milan*, Vol. VI.

Barnard, K. H.:

1925. A Monograph of the Marine Fishes of South Africa. Pt. I. *Ann. S. African Mus.*, Vol. XXI.

Bean, T.:

1890. New Fishes Collected off the Coast of Alaska and the Adjacent Region Southward. *Proc. U. S. Nat. Mus.*, Vol. XIII.

BEEBE, W.:

1931a. Bermuda Oceanographic Expeditions 1929-1930. Introduction. *Zoologica*, Vol. XIII, No. 1.

1931b. Bermuda Oceanographic Expeditions 1929-1930. List of Nets and Data. *Zoologica*, Vol. XIII, No. 2.

1932. Bermuda Oceanographic Expeditions 1931. Individual Nets and Data. *Zoologica*, Vol. XIII, No. 3.

1933. Deep-sea Fishes of the Bermuda Oceanographic Expeditions. Introduction. *Zoologica*, Vol. XVI, No. 1.

1935. Deep-sea Fishes of the Bermuda Oceanographic Expeditions. *Zoologica*, Vol. XX, No. 1.

1937a. The Templeton Crocker Expedition. II. Introduction, Itinerary, List of Stations, Nets and Dredges. *Zoologica*, Vol. XXII, No. 2.

1937b. Preliminary List of Bermuda Deep-sea Fish. Based on the Collections from 1500 Metre-net Hauls, Made in an Eight-mile Circle South of Nonsuch Island, Bermuda. *Zoologica*, Vol. XXIII, No. 14.

BEEBE, W., & CRANE, J.:

1934. Classified Résumé of Organisms Observed from the Bathysphere. (in "Half Mile Down", by William Beebe, Appendix G., Harcourt Brace and Co., New York).

1936. Deep-sea Fishes of the Bermuda Oceanographic Expeditions. Family Serrivomeridae. Part I: Genus *Serrivomer*. *Zoologica*, Vol. XX, No. 3.

1937. Deep-sea Fishes of the Bermuda Oceanographic Expeditions. Family Serrivomeridae. Part II: Genus *Platuronides*. *Zoologica*, Vol. XXII, No. 26.

BORODIN, N. A.:

1931. Atlantic Deep-sea Fishes. *Bull. Mus. Comp. Zool. Harvard Coll.*, Vol. LXXII, No. 3.

BRANDT, J F.:

1854. Remarques sur le Memoire de M. Lowe, suivies d'une Planche Representant le Nouveau Genre de Poisson. *Mem. Acad. Sci. St. Petersbourg, Savants etrangers*, Vol. VII.

BRAUER, A.

1906. Die Tiefsee-Fische. I. Systematischer Teil. *Wiss. Ergeb. Deutsch. Tiefsee-Exp. Valdivia*, Vol. 15, Lief 1.

GARMAN, S.:

1899. The Fishes. Report on an Exploration . . . by the U. S. Fish Commission Steamer "Albatross", during 1891. *Mem. Mus. Comp. Zool. Harvard Coll.*, Cambridge, Mass.

GILBERT, C. H.:

1905. The Deep-sea Fishes of the Hawaiian Islands. *Bull. U. S. Fish Comm.*, Vol. XXIII, Part II, Section II.

GILL, T. & RYDER, J. A.:

1883. Diagnosis of New Genera of Nemichthyoid Eels. *Proc. U. S. Nat. Mus.*, Vol. VI.

GOODE, G. B., & BEAN, T. H.:

1895. Oceanic Ichthyology. A Treatise on the Deep-sea and Pelagic Fishes of the World. *Special Bull. U. S. Nat. Mus.*

GÜNTHER, A.:

1870. Catalogue of the Fishes in the British Museum, London, Vol. VIII.

1878. Preliminary Notices of Deep-sea Fishes Collected during the voyage of H. M. S. "*Challenger*". *Ann. Mag. Nat. Hist.*, London, Series V, Vol. II.

1887. Deep-sea Fishes. *Report Scient. Results "Challenger", Zool.*, London, Vol. XXII.

JORDAN, D. S.:

1923. A Classification of Fishes, including Families and Genera as Far as Known. Stanford University, California.

JORDAN, D. S. & DAVIS, B. M.:

1888. A Preliminary Review of the Apodal Fishes, or Eels, Inhabiting the Waters of America and Europe. *Rep. U. S. Fish Comm.*, Vol. XVI.

JORDAN, D. S., & EVERMANN, B. W.:

1896. The Fishes of North and Middle America. Pt. I. *Bull. U. S. Nat. Mus.*, Vol. XLVII.

JORDAN, D. S., & GILBERT, C. S.:

1880. Description of a New Species of *Nemichthys* (*N. avocetta*) from Puget Sound. *Proc. U. S. Nat. Mus.*, Vol. III.

LEA, E.:

1913. Muraenoid Larvae from the "Michael Sars" North Atlantic Deep-sea Expedition, 1910. *Rep. Scien. Res. "Michael Sars", Bergen*, Vol. III, Part 1.

LOWE, R. T.:

1852. An account of Fishes Discovered or Observed in Madeira Since the Year 1842. *Ann. Mag. Nat. Hist.*, Series II, Vol. X.

MOWBRAY, L.:

1922. Habit Note on Snipe Eel. *Copeia*, No. 108.

MURRAY, J., & HJORT, J.:

1912. The Depths of the Ocean. London.

NORMAN, J. R.:

1930. Oceanic Fishes and Flatfishes Collected 1925-1927. *Discovery Reports*, Vol. II.

PAPPENHEIM, P.:

1914. Die Fische der Deutschen Sudpolar-Expedition (1901-1903). II. Die Tiefseefische. *Deutche Sudpolar-Exp., Berlin, Zool.*, Vol. VII, Part 2.

PARR, A. E.:

1932. Deep Sea Eels, Exclusive of Larval Forms. *Bull. Bingham Ocean. Coll. New Haven.* Vol. III, Art. 5.

1934. Report on Experimental Use of a Triangular Trawl . . . with an Account of the Fishes Obtained . . . *Bull. Bingham Ocean. Coll. New Haven.* Vol. IV, Art. 6.

ROULE, L.:

1911. Sur Quelques Larves de Poissons Apodes. *C. R. Acad. Scien. Paris*, Vol. CLIII.

1914a. Diagnoses Preliminaires des Larves de Poissons Apodes . . . *Bull. Inst. Oceangr. Monaco*, No. 292.

1914b. Sur les Phases Larvaires Tiluriennes de Poissons Apodes Appartenant a la Famille des Nemichthyidés. *C.R. Acad. Sc., Paris*, Vol. CLVIII.

1919. Poissons Provenant des Campagnes du Yacht "Princesse-Alice" . . . *Res. Camp. Scient. du Prince de Monaco*, Vol. LII.

ROULE, L., & ANGEL, F.:

1931. Observations et Rectifications Concernant Divers Poissons Recueillis par S. A. S. le Prince Albert Ier de Monaco au Cours des Campagnes 1911 a 1914. *Bull. l'Inst. Oceanogr. Monaco*, No. 581.

1933. Poissons Provenant des Campagnes du Prince Albert Ier de Monaco. *Res. Camp. Sci. Monaco.*, Vol. LXXXVI.

ROULE, L., & BERTIN, L.:

1924. Notice Préliminaire sur la Collection des Némichthyidés Recueillis par l'Expédition du "Dana" (1920-1922), Suivie de Considérations sur la Classification de Cette Section des Poissons Apodes. *Bull. Mus. Paris,* Vol. XXX, pp. 61-67.

1929. Les Poisson Apodes Appartenant au Sous-Ordre des Nemichthydiformes. *"Dana" Exped.* 1920-1922, *Oceanogr. Rep.,* No. 4.

SCHMIDT, J.:

1912. Contributions to the Biology of Some North Atlantic Species of Eels. *Vidensk. Medd. f. Dansk naturh. Forening, Kjobenhavn,* Vol. LXIV.

TOWNSEND, C. H., & NICHOLS, J. T.:

1925. Deep Sea Fishes of the "Albatross" Lower California Expedition. *Bull. Amer. Mus. Nat. Hist. New York,* Vol. LII.

TREWAVAS, E.:

1932. A Contribution to the Classification of the Fishes of the Order Apodes, Based on the Osteology of Some Rare Eels. *Proc. Zool. Soc. London,* 1932, Part 3.

VALLIANT, L.:

1888. Poisson, Exp. Scient. "Talisman et Travailleur." Paris.

WEBER, M.:

1913. Die Fische der "Siboga"-Expedition, Leiden.

WEBER, M. & BEAUFORT, L. F. DE:

1916. The Fishes of the Indo-Australian Archipelago, Leiden, Vol. III.

ZUGMAYER, E.:

1914. Diagnoses de Quelques Poissons Nouveaux Provenant des Campagnes du Yacht "Hirondelle II" (1911-1913). *Bull. Inst. Ocean., Monaco,* No. 288.